TROVIS 6400 Automation System
TROVIS 6493 Compact Controller

Mounting and Operating Instructions

EB 6493 EN

Firmware version 4.03

Edition April 2012

TROVIS® Electronics from SAMSON

Definitions of the signal words used in these instructions

⚠ ***DANGER!***
indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING!
indicates a hazardous situation which, if not avoided, could result in death or serious injury.

NOTICE
indicates a property damage message.

Note: *Supplementary explanations, information and tips*

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Firmware revisions	
4.01 (old)	**4.02** (new)
	Internal modifications
4.02 (old)	**4.03** (new)
	Internal modifications

1 Important safety instructions

For your own safety, follow these instructions concerning the mounting, start-up and operation of the compact controller:

- The compact controller may only be mounted, started up or operated by trained and experienced personnel familiar with the product.
  According to these Mounting and Operating Instructions, trained personnel refers to individuals who are able to judge the work they are assigned to and recognize possible dangers due to their specialized training, their knowledge and experience as well as their knowledge of the relevant standards.
- The controller is intended for use in low-voltage installations.
  For wiring and maintenance, you are required to observe the relevant safety regulations.

To avoid damage to any equipment, the following also applies:

- Proper shipping and appropriate storage are assumed.

2 Device version

2.1 Article code

TROVIS 6493-032 Compact Controller	x
Power supply	|
90 to 250 V AC	4
24 V AC/DC	5

2.2 Accessories

Accessories	Order no.
TROVIS-VIEW Configuration and Operator Interface.....	6661*
Infrared adapter (RS-232).....	8864-0900
Bracket for infrared adapter...	1400-9769
USB to RS-232 adapter.....	8812-2001

* The TROVIS-VIEW software is a common operator interface for various smart SAMSON devices. The software together with a device-specific module allow the configuration and parameterization of the device.
The device-specific module for TROVIS 6493 can be downloaded free of charge from the SAMSON website (Services > Software > TROVIS-VIEW).
Additional information on TROVIS-VIEW (e.g. system requirements) can found on the SAMSON website and in the Data Sheet T 6661 EN.

3 Installation

The TROVIS 6493 Compact Controller is designed for panel mounting. Its front case has the dimensions 48 x 96 mm.

1. Prepare a panel cut-out with the dimensions $45^{+0.6}$ x $92^{+0.8}$ mm.
2. Push the compact controller into the panel cut-out from the front.
3. Insert supplied mounting clips (2) in the notches on the top and bottom (Fig. 1).
4. Turn the threaded rods in the direction of the control panel using a screwdriver, clamping the case against the control panel.

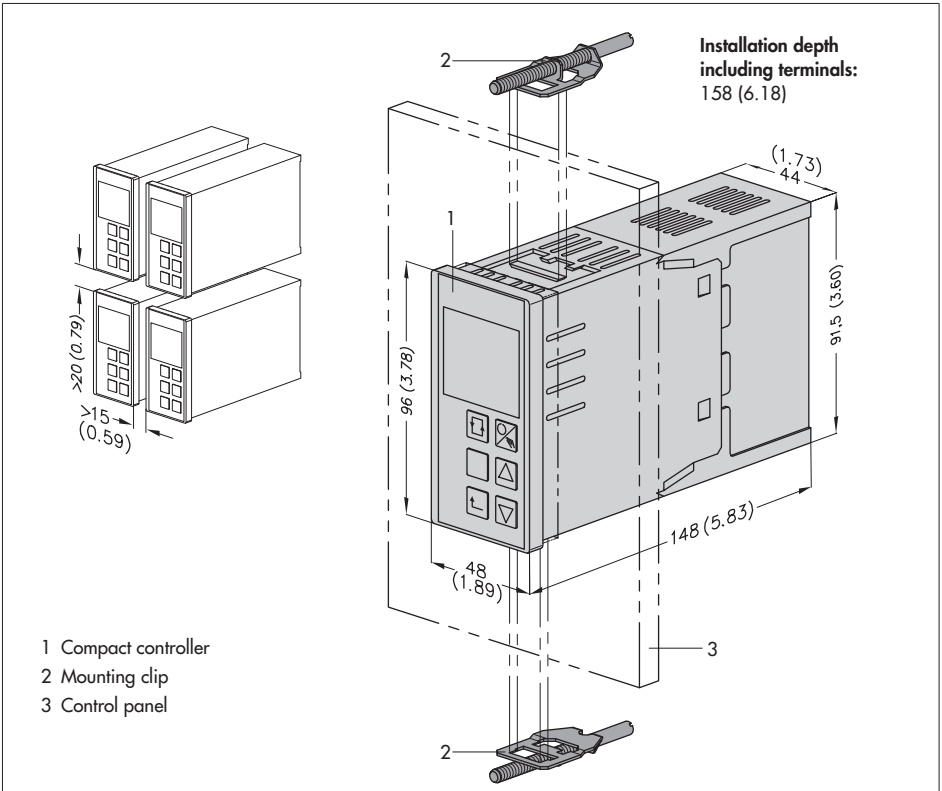


Fig. 1 · Installation · Dimension in mm (inch)

4 Electrical connection

⚠ ***Risk of electric shock!***
When installing electric cables, you are required to observe the regulations governing electrical power plant installation in the country where the controller is to be installed.

Installation notes

- Install the power supply lines and the signal lines separately! Do not install them parallel to each other! To improve noise immunity, observe a minimum distance of 10 cm between the power cable and the measuring input lines.
- To avoid measurement errors or other disturbances, use shielded cables for the analog and binary signal lines. Ground the shield at one end, either at the controller inlet or at the control cabinet outlet, using the largest possible cross-section. Connect the central grounding point and the PE grounding conductor with a cable ≥ 10 mm² using the shortest route.
- Inductances in the control cabinet, e.g. contactor coils, are to be equipped with suitable interference suppressors (RC elements).
- Control cabinet elements with high field strength, e.g. transformers or frequency converters, are to be shielded with separators providing a good ground connection.

The controller has screw terminals for 1.5 mm² wires (0.5 to 1.5 mm² wire cross-section).

The lines are connected to the terminal strips 1 and 2 as shown in the following wiring diagram (Fig. 2).

Transmitter supply

The controller has a supply output to power a maximum of two two-wire transmitters (20 V DC, 45 mA) and the binary input.

Resistance thermometers

The analog inputs IN1 and IN2 are designed for the connection of resistance thermometers Pt 100 and Pt 1000 in a three-wire circuit. The resistance of each connection lead must be the same and not exceed 15 Ω. Lead calibration is not necessary.

Resistance thermometers can also be connected in two-wire circuits. In this case, connect a jumper between the controller terminals. Take into account that the lead resistance may reach several ohms over long distances, causing the measured value to be considerably distorted. This measured value can be compensated for by a correction value. Refer to section 6.4.7 (-CO-F.FOR Feedforward control) on page 52.

Potentiometers

The analog inputs IN1 and IN2 are designed for the connection of a potentiometer with two-wire or three-wire connection.
A potentiometer is used, for example for position feedback of an electrical actuator or for input of an external set point.

Generally for potentiometers, we recommend performing a zero and span calibration. Refer to section 6.9.5 (-CO- ADJ Calibration of analog inputs and analog output) on page 83.

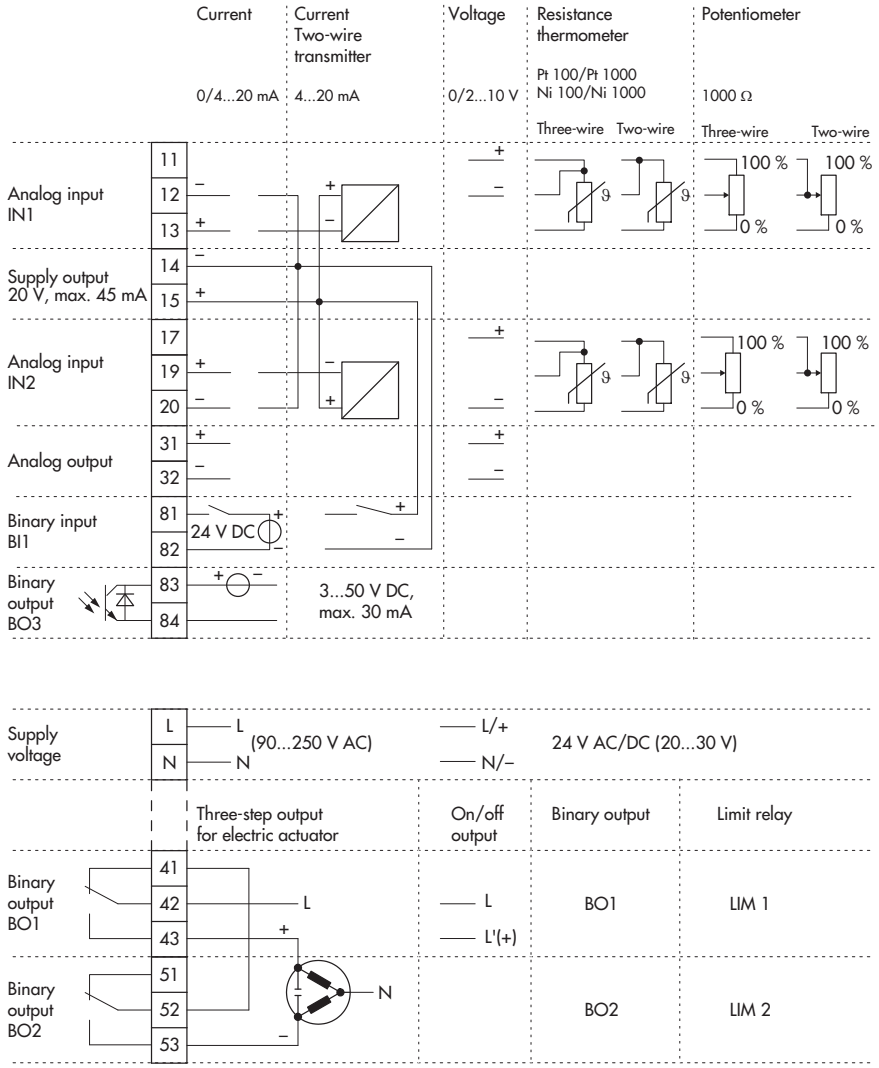


Fig. 2 · Electrical connection

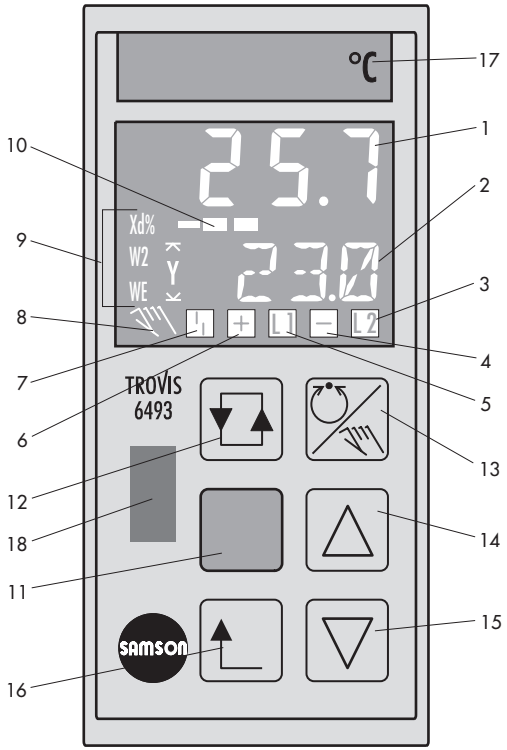
5 Operation

The TROVIS 6493 Compact Controller is a microprocessor-controlled compact controller with a flexible software concept for the automation of industrial and processing plants. The controller is suitable for use in simple control loops as well as for solving more complex control tasks. The flexible software concept allows the user to configure control circuits without modifying the hardware. The functions are stored in a read-only memory and can be adapted to the specific requirements of the respective control system.

Configuration, parameterization and operation of the TROVIS 6493 Compact Controller can be performed either directly using the keys on the front panel (refer to section 5.2) or using the TROVIS-VIEW Configuration and Operator Interface (see section 10).
Principally, there are two levels which provide different key functions and different displays: the operating level and the setup level. The readings in the display (see section 5.1) and the functions of the keys (see section 5.2) differ depending on which level the controller is in.

5.1 Display

No.	Operating level Depending on the level selected, the following variables and operating states are shown on the display:	Setup level
1	Controlled variable X	Designations, settings and values of the functions and parameters (→ section 11.1)
2	Value assumed by W, W2, WE, Y or Xd	
3	Limit relay L2 active	Not displayed
4	Three-step output –	Not displayed
5	Limit relay L1 active	Not displayed
6	Three-step output + or on/off output	Not displayed
7	Fault alarms (see section 6.2.3)	Not displayed
8	Hand icon displayed in manual mode, no icon in automatic mode	Not displayed
9	Press key to display W, W2, WE, Y or Xd% in sequence. The associated value appears in (2). W2 and WE only when they have been activated (see section 6.3.1).	Fast access to parameters: Every time you press, the decimal point of a parameter is shifted one place to the right.
10	Bar display of Xd in percent	Not displayed



1 Controlled variable X
2 W, W2, WE, Y or XD
3 Limit relay L2 active
4 Three-step output –
5 Limit relay L1 active
6 Three-step output +
7 Fault alarm
8 Hand icon
9 After pressing W, W2, Y or XD is shown with the value in 2
10 Bar reading of XD in %
11 Enter key
12 Selector key
13 Manual/automatic key
14 Cursor key (increase, scroll forwards)
15 (decrease, scroll backwards)
16 Escape key
17 Label (exchangeable)
18 Infrared interface

5.2 Control keys

The keys' function varys depending on which level the controller is in.

Key	Operating level	Setup level
Enter key (yellow)	– Access setup level – Activate set point* * Only if the set point name (W, W2 or WE) **blinks** on the display	– Open menus, functions and parameters – Confirm settings
Selector key	– Switch between readings: W Internal set point 1 W2* Internal set point 2 WE* External set point Y Manipulated variable Xd% Error * Only when they have been configured (see section 6.3.1)	– Access parameter level – Jump within the value range in the parameter level – Shift the decimal point one place to the right
Manual/ automatic key	– Change from manual to automatic mode and vice versa* * In manual mode, the hand icon appears in the display.	No function
Cursor keys	– Change the value of internal set point* – Change the control output** * Only when selected using the selector key. ** Only when Y has been selected using the selector key or when manual mode ( ) has been selected.	– Browse within menus, functions and parameters – Change function settings and parameter values
Escape key	– Display currently valid set point	– Return to the operating level stepwise
No keys pressed	After approx. 5 minutes, the reading on the display changes back to the currently valid set point Exception: in manual mode and when the manipulated variable is displayed	Changes back to operating level after approx. 5 minutes

5.3 Operating level

The controller is in this level when control operation is active. Key information on the control process are displayed in this level. The default display shows the controlled variable X, error signal Xd, the currently valid set point W, W2 or WE, the active limit relay as well as information on the three-step output, if applicable.

Note: *Other variables, such as the error in %, can be displayed instead of the currently valid set point. To do this, press the selector key until the required variable is displayed. The following variables can be selected: internal set point W, manipulated variable Y, error Xd% and, depending on the configuration in the SETP menu, the internal set point W, W2 and the external set point WE.*

The following actions can be performed in the operating level:

- Changing the internal set point (→ section 5.3.1).
- Switching between set points (→ section 5.3.2).
- Switching to the manual mode and changing the control output (→ section 5.3.3).

5.3.1 Changing the internal set point

Select internal set point W or W2.

Increase the set point.
Decrease the set point.

5.3.2 Switching between set points

Select set point W, W2 or WE.
If a set point is not active, the set point name (W, W2 or WE) blinks on the display.

Activate the set point.
The set point name (W, W2, WE) stops blinking.
The previously active set point is deactivated.

5.3.3 Switching over to manual mode and changing the control output

Switch to manual mode.
The hand icon and the control output Y (manipulated variable) appear on the display.

Increase the manipulated variable.
Reduce the manipulated variable.

Return to automatic mode

Return to automatic mode.
The hand icon is no longer displayed. The currently valid set point is shown on the display.

Note: *If required, you can display the control output (manipulated variable) Y by pressing the key.*

5.4 Setup level

This level enables you to adapt the compact controller to the control task. You can adapt preset functions to your specific needs and change parameters. The functions are arranged in nine main menus:

- PAR: Control parameters
- IN: Input
- SETP: Set point
- CNTR: Controller
- OUT: Output
- ALRM: Limit relays
- AUX: Additional functions
- TUNE: Start-up adaptation
- I-O: Process data

Section 11.1 describes all the menus, functions and parameters.

5.4.1 Configuring the controller

To set a function or parameter, you need to know the abbreviated code used for the function/parameter and the menu where it can be found. Refer to section 11.1 for an overview of these codes. Section 5.4.3 describes an example on how to configure the controller.

To proceed:

The controller is in the operating level.

- Open the setup level.
  Display: PAR (Control parameters menu)

  If the function you want to configure is located in a different menu:
  - Select the required menu: IN, SETP, CNTR, OUT, ALRM, AUX, TUNE or I-O
- Open menu.
  Display: -CO- and abbreviated code of the first function in the current menu

  If you want to configure a different function:
  - Select the required function.
- Open the function.
  Display: Current function setting
- Activate the function's editing mode.
  Current function setting blinks.

Note: *Every time you go to the first function after opening the setup level, you are prompted to enter the key number (display: - - - - and KEY).* ***You only need to enter the key number if a key number has already been assigned to the controller (→ section 5.4.2). If this is not the case, entry of the key number can be skipped by pressing the enter key (■).***

- Change function setting.
- Confirm setting.
- Go to the parameter level.
  Display: -PA-
- Open the parameter level.
  Display: code of the first parameter

  If you want to configure a different parameter:
  - Select the required parameter.

- Activate the parameter's editing mode.
  The code for the function's parameter blinks.
- Change parameter setting.
- Confirm setting.

After completing all parameter settings:

- Press until the controller is back in the operating level.

Note: *The controller automatically returns to the operating level five minutes after the last key has been pressed.*

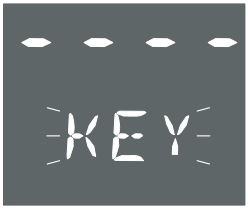
5.4.2 Key number

The compact controller can be operated with or without a key number. Factory default allows the controller to be operated without a key number. Operation with a key number is only activated after a user-defined key number has been assigned. The service key number is required to define a user-defined key number.

Note: *The overriding service key number is specified at the end of the printed Mounting and Operating Instructions. This key number allows you to change configuration settings and parameter values regardless of the user-defined key number.*
We recommend removing the page containing the service key number or making it unreadable to prevent misuse.

Prompt for key number

Every time you go to the first function or parameter after opening the setup level, you are prompted to enter the key number:



KEY blinks.

Note: *When this reading appears, you can change the user-defined key number. See 'Activate/deactivate operation with key number'.*

Operation without key number

Exit prompt for key number.

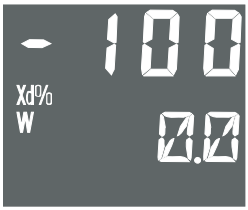
Operation with key number

Enter the valid key number. In this example it is 12.

Exit prompt for key number.

Note: *If you enter an incorrect key number, you are prompted again to enter the key number. In this case, a '1' appears on the display instead of - - - -.*

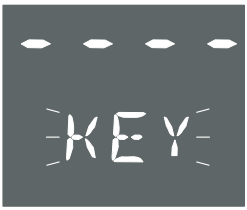
Activate/deactivate operation with key number



The controller is in the operating level.
The reading on the display looks like this.

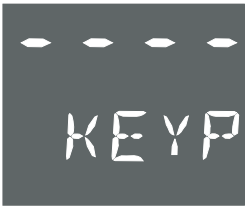
- Open the setup level.

- Open the parameter level.



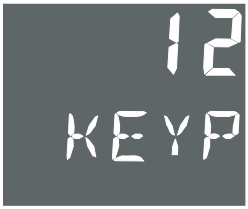
- Activate prompt for key number.
  KEY blinks.

- Enter the service key number.



- Confirm the service key number.
  Display: - - - - and KEYP

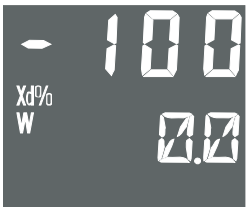
Note: *A number instead of - - - - means that a key number is already active. The reading shown is the valid key number.*



Enter your own key number (12 in this example).

Note: *To deactivate operation with key number, select - - - - in the display.*

Exit prompt for key number.
The controller returns to the setup level.



Press until the controller is back in the operating level.

5.4.3 Example showing configuration and parameterization

The compact controller is to configured to be a PID controller. The associated proportional-action coefficient (KP) is to be set to 1.5. Refer to the overview in section 11.1. This overview shows that time behavior is determined by the C.PID function in the CNTR menu.

→.... → ..... ↓ or → ..... → .....

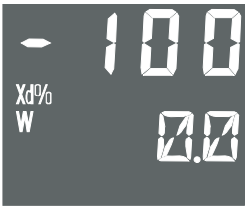
Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Control structure and functions				
CNTR	**C.PID**	P CP.YP	P	C.PID/CP.YP
	Control algorithm	**PI CP.YP**	PI	C.PID/CP.YP
		Pd CP.YP	PD	C.PID/CP.YP
		PId CP.YP	PID	C.PID/CP.YP
		PPI CP.YP	P²I	C.PID/CP.YP

* The default setting is written in **bold**.

The proportional-action coefficient is set using the KP parameter.

△ ↓ or □ →..... .△ ↓ and □ , followed by ↵

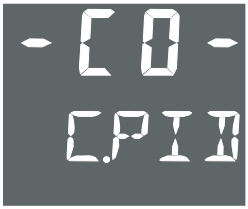
Parameter selection	Parameter description	Value range*	Refer to section
KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]	6.4.1
TN	Reset time	[1 … **120** … 9999 s]	
TV	Derivative-action time	[1 … **10** … 9999 s]	
TVK1	Derivative-action gain	[0.10 … **1.00** … 10.00]	
Y.PRE	Operating point	[–10.0 **… 0.0** … 110.0]	
DZXD	Dead zone error XD	[**0.0** … 110.0 %]	
⩡ DZXD	Minimum effective error XD	[**–110.0 %** … ⩠ DZXD]	
⩠ DZXD	Maximum effective error XD	[⩡ DZXD … **110.0 %**]	



The controller is in the operating level.
The reading on the display looks like this.

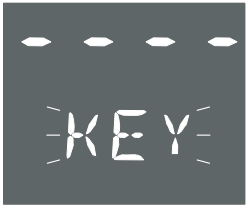
□ Open the setup level.
Display: PAR (Control parameters menu)

△ 3x Select CNTR (Controller).



Enter menu.
Display: -CO- and C.PID (first function in CNTR menu)

Open function.
Display: PI (current setting of C.PID function)

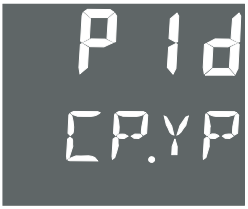


Activate the function's editing mode.
Display: prompt for key number

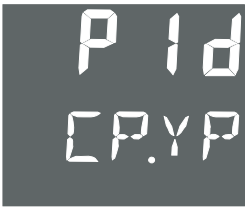
Only for operation with key number:

Enter the valid key number (27 in the example).

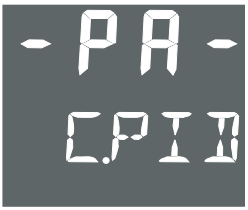
Exit prompt for key number.
The CP.YP function can be edited.
PI blinks.



2x Change the PI control algorithm to PID algorithm.



Confirm setting.
The editing mode is exited.



Change to the parameter level.
Display: -PA- and C.PID/CP.YP blink in alternating sequence

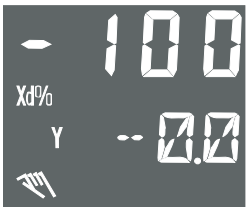
Open the parameter level:
Display: KP (the first parameter of the C.PID function)

Activate the parameter's editing mode.
KP blinks.

Change the proportional-action coefficient KP to 1.5.

Confirm setting.
The editing mode is exited.

Note: *If you want to change other parameters in the function setting, select these parameters ( ) and repeat the steps in the gray-shaded backgroand.*



4x Return to the operating level.

5.5 Overview of operating steps

In following, the operation of the controller is shown in schematic form:

① Open setup level

② Enter menu

③ Select function/parameter

④ Display setting

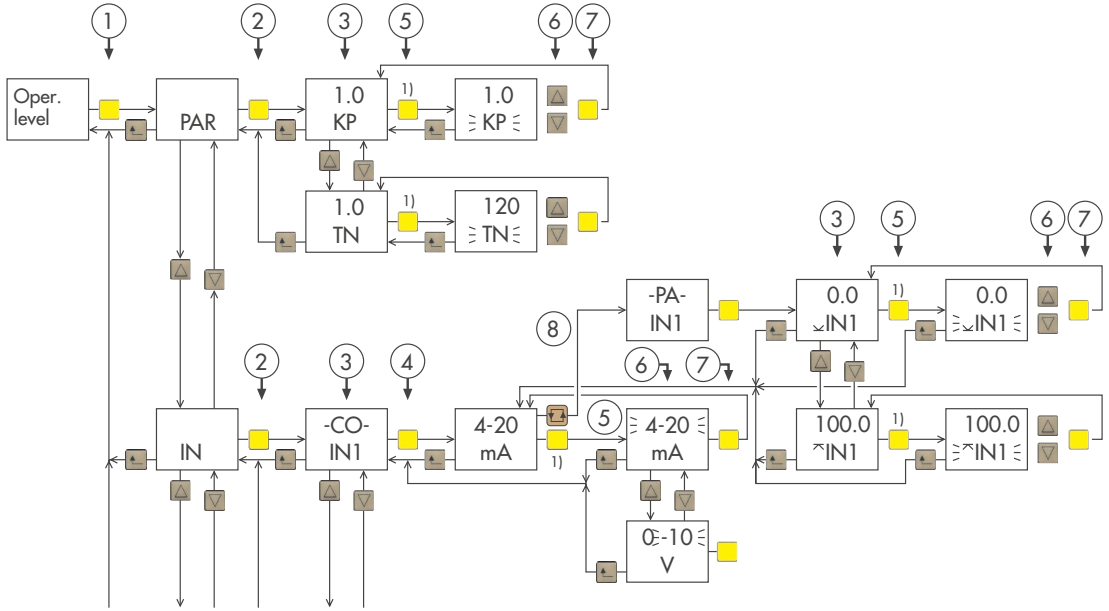
⑤ Activate the editing mode to change setting

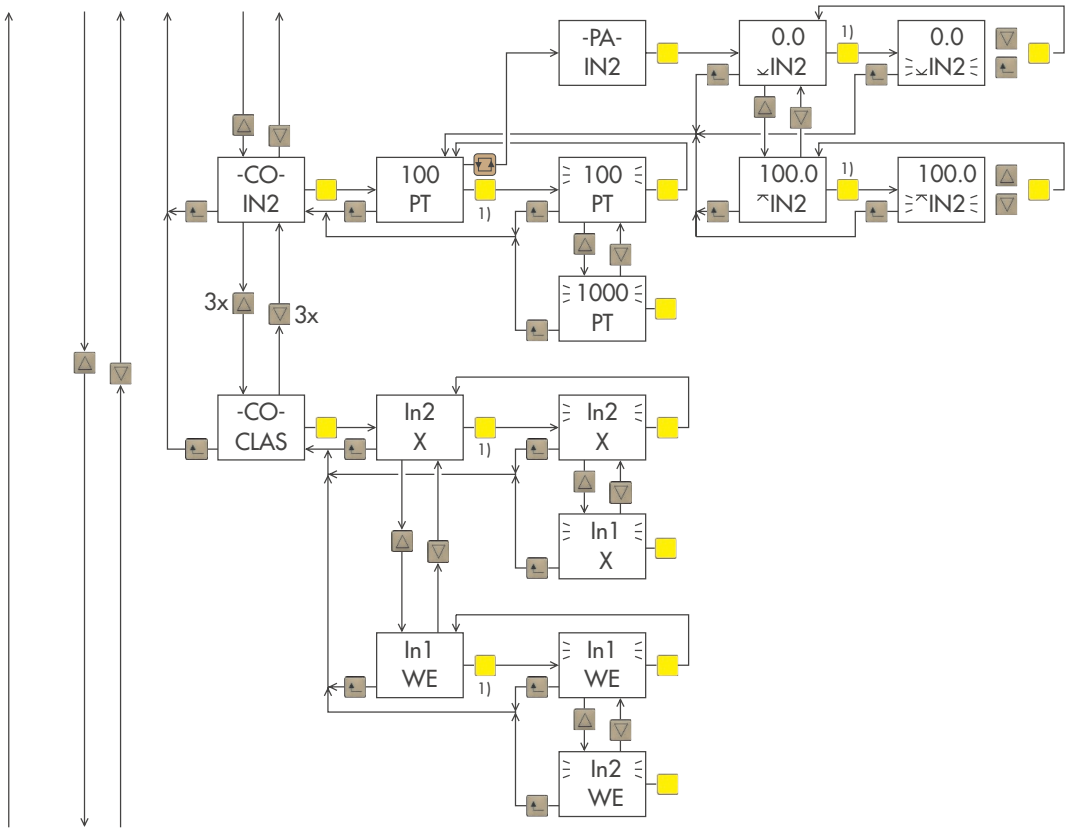
⑥ Change setting

⑦ Confirm setting

⑧ Open parameter level

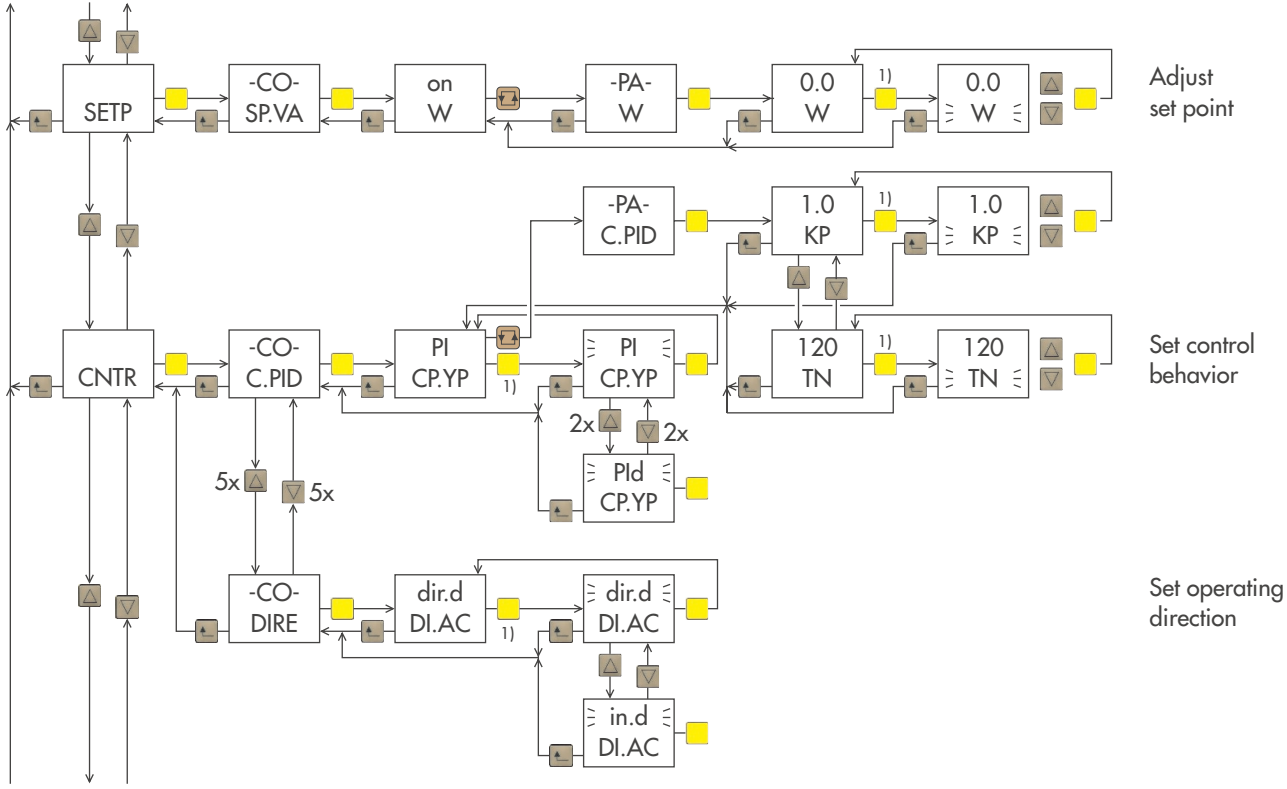
1) Every time you open the setup level and before you activate the editing mode for the first time, you are prompted to enter the key number. If settings are to be made without entering the key number, press the enter key again to activate the editing mode. Configuration is enabled until you exit the setup level.

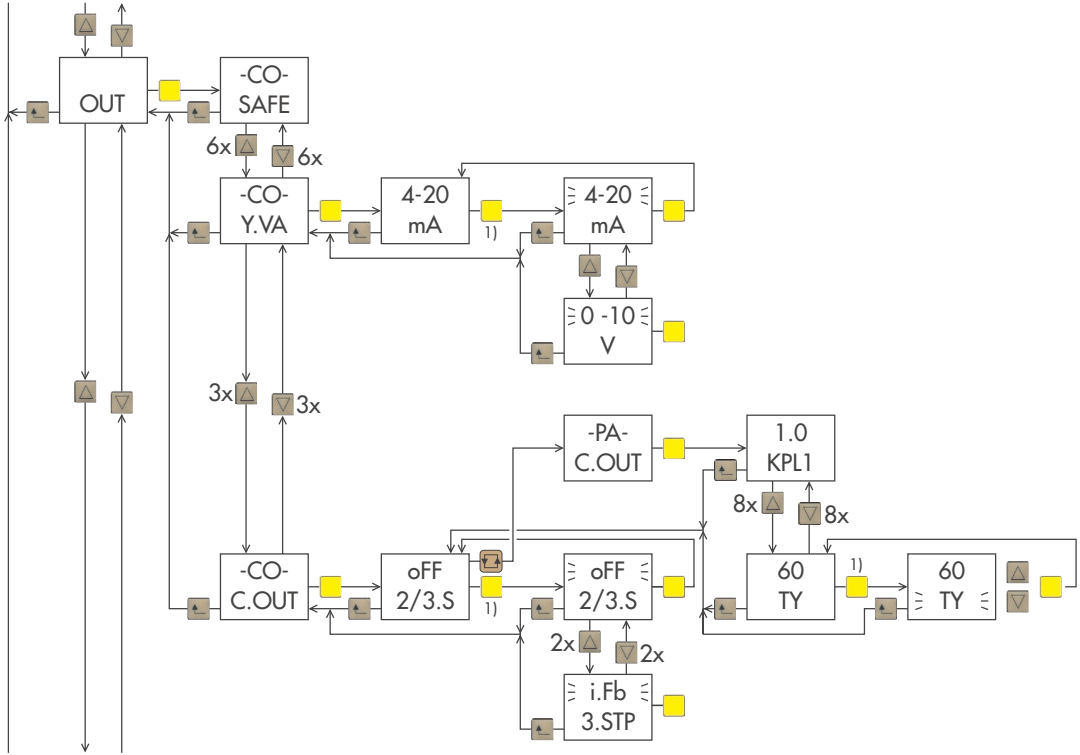

1
2
3
5
6
7
Oper. level
PAR
1.0 KP
1.0 KP
1.0 TN
120 TN
1)
3
5
6
7
-PA- IN1
0.0 IN1
0.0 IN1
8
6
7
2
3
4
5
IN
-CO- IN1
4-20 mA
4-20 mA
100.0 IN1
100.0 IN1
0-10 V
Set control parameters
Input IN1
Set input signal and measuring range



Input IN2
Set input signal and measuring range

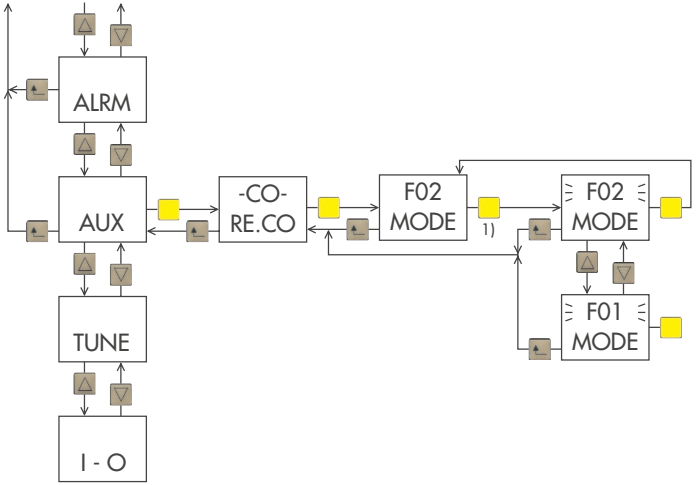
Assign input variable


SETP
-CO-
SP.VA
on
W
-PA-
W
0.0
W
1)
0.0
W
Adjust
set point
-PA-
C.PID
1.0
KP
1)
1.0
KP
CNTR
-CO-
C.PID
PI
CP.YP
1)
PI
CP.YP
120
TN
1)
120
TN
Set control
behavior
2x
2x
PId
CP.YP
5x
5x
-CO-
DIRE
dir.d
DI.AC
1)
dir.d
DI.AC
in.d
DI.AC
Set operating
direction



Analog output:
Set signal range

Set three-step output



Set restart conditions
after power failure

6 Functions of the compact controller

In this section, all functions of the setup level are described. There are nine menus in the setup level which contain the functions and their parameters. Each menu is dedicated to the functions of a certain topic:

- PAR: Control parameters
- IN: Input
- SETP: Set points
- CNTR: Controller
- OUT: Output
- ALRM: Limit relays
- AUX: Additional functions
- TUNE: Start-up adaptation
- I-O: Process data

Section 11.1 contains an overview of all the menus, functions and parameters.

Functions are identified in the display by -CO-, whereas the parameter level is identified by -PA-.

Functions of the binary input BI1

– SETP menu	-CO- SP.FU/RAMP	Start set point ramp (→ section 6.3.2)
– SETP menu	-CO- SP.FU/CH.SP	Switch over set points (→ section 6.3.2)
– CNTR menu	-CO- AC.VA	Increase/decrease actual value (process variable) (→ section 6.4.8)
– OUT menu	-CO- SAFE	Activate constant output value (→ section 6.5.1)
– OUT menu	-CO- MA.AU	Manual/automatic switchover (→ section 6.5.2)
– OUT menu	-CO- RAMP	Start output ramp (→ section 6.5.4)
– OUT menu	-CO- BLOC	Locking manipulated variable (→ section 6.5.5)
– OUT menu	-CO- B.OUT	Activate binary outputs (→ section 6.5.11)

6.1 PAR menu: Control parameters

This menu does not contain any functions. When you open this menu, the controller immediately jumps to the parameter level -PA-. It allows you to quickly set the control parameters.

Note: *The control parameters can also be set in the CNTR menu (C.PID function). Refer to section 6.4.1.*

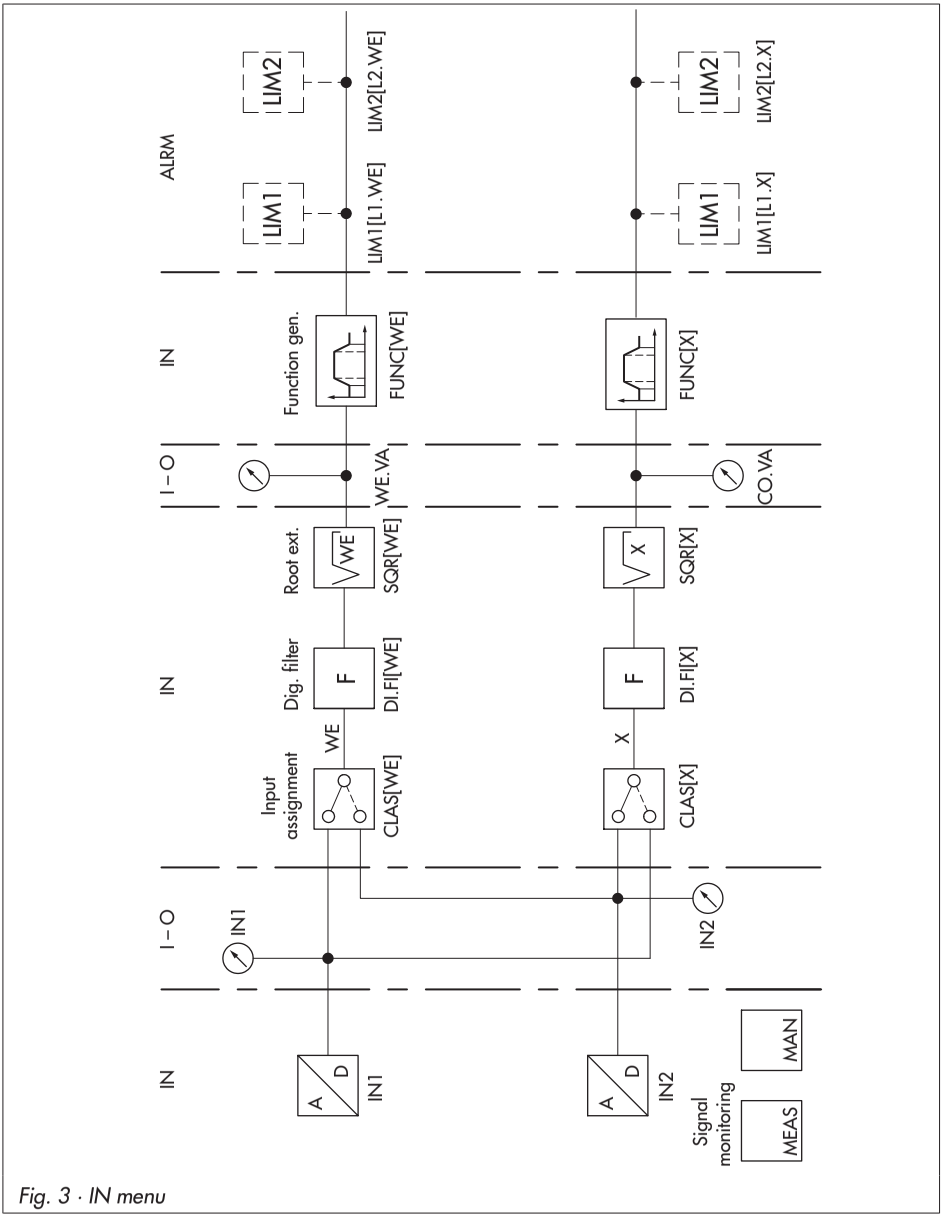

IN
I – O
IN
IN
I – O
IN
ALRM
IN1
A
D
IN1
Signal monitoring
MEAS
MAN
IN2
A
D
IN2
Input assignment
CLAS[WE]
WE
Dig. filter
DI.FI[WE]
Root ext.
SQR[WE]
WE.VA
Function gen.
FUNC[WE]
LIM1
LIM2
LIM1[L1.WE]
LIM2[L2.WE]
X
CLAS[X]
F
DI.FI[X]
SQR[X]
CO.VA
FUNC[X]
LIM1
LIM2
LIM1[L1.X]
LIM2[L2.X]

Fig. 3 · IN menu

PAR			
	KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]
	TN	Reset time	[1 … **120** … 9999 s]
	TV	Derivative-action time	[1 … **10** … 9999 s]
	Y.PRE	Operating point	[–10.0 … **0.0** … 110.0 %]

6.2 IN menu: Input functions

The analog inputs (IN1, IN2) are set in the IN menu.

6.2.1 -CO- IN1: Input signal IN1

This function enables you to define the input signal type and range for the analog input IN1.

IN	**-CO- IN1**	Input signal IN1	
	0–20 mA	0 to 20 mA	
	4–20 mA	4 to 20 mA	
	0–10 V	0 to 10 V	
	2–10 V	2 to 10 V	
	100 PT	Pt 100 (–100 … 500 °C)	Resistance values → section 11.3
	1000 PT	Pt 1000 (–100 … 500 °C)	Resistance values → section 11.3
	100 NI	Ni 100 (–60 … 250 °C)	Resistance values → section 11.3
	1000 NI	Ni 1000 (–60 … 250 °C)	Resistance values → section 11.3
	0–1KOHM	0 to 1000 Ω	
	-PA- IN1		
	⩡ IN1	Lower measuring range value	[–999.0 … **0.0** … ⩠ IN1]
	⩠ IN1	Upper measuring range value	[⩡ IN1 … **100.0** … 9999]

6.2.2 -CO- IN2: Input signal IN2

This function enables you to define the input signal type and range for the analog input IN2.

IN	**-CO- IN2**	Input signal IN2	
	0–20 mA	0 to 20 mA	
	4–20 mA	4 to 20 mA	
	0–10 V	0 to 10 V	
	2–10 V	2 to 10 V	
	100 PT	Pt 100 (–100 … 500 °C)	Resistance values → section 11.3
	1000 PT	Pt 1000 (–100 … 500 °C)	Resistance values → section 11.3
	100 NI	Ni 100 (–60 … 250 °C)	Resistance values → section 11.3
	1000 NI	Ni 1000 (–60 … 250 °C)	Resistance values → section 11.3
	0–1KOHM	0 to 1000 Ω	
	-PA- IN2		
	⊻ IN2	Lower measuring range value	[–999.0 … **0.0** … ⊼ IN2]
	⊼ IN2	Upper measuring range value	[⊻ IN2 … **100.0** … 9999]

6.2.3 -CO- MEAS: Signal monitoring

This function enables you to define whether the signal ranges of the analog inputs IN1 and IN2 are to be monitored either for a signal exceeding or falling below the signal range.

When the signal exceeds or falls below the rated signal range, the fault alarm output (BO3) is activated and the alarm icon appears on the display. In addition, the signal violation is indicated by one of the following readings blinking on the display:

- __o1: Signal exceeds the rated signal range at analog input IN1 or at analog inputs IN1 and IN2
- __u1: Signal falls below the rated signal range at analog input IN1 or at analog inputs IN1 and IN2
- __o2: Signal exceeds the rated signal range at analog input IN2
- __u2: Signal falls below the rated signal range at analog input IN2

Note: *The controller can be configured to change to the manual mode when a signal range violation occurs. Refer to section 6.2.4.*

IN	**-CO- MEAS**	Signal monitoring
	oFF ME.MO	Off
	IN1 ME.MO	Analog input IN1
	IN2 ME.MO	Analog input IN2
	ALL ME.MO	Analog input IN1 and IN2

6.2.4 -CO- MAN: Switch to manual mode in case of signal failure

This function enables you to define whether the controller automatically switches to manual mode ⩫ after a signal range violation when the signal range monitoring is active (-CO- MEAS ≠ oFF ME.MO).

- **F01 FAIL:** The controller switches to manual mode and the output value Y1K1 is issued. The output value Y1K1 only becomes effective when the controller is in automatic mode at the time when the signal range violation occurred.
- **F02 FAIL:** The controller switches to manual mode and the last manipulated variable is issued.

In manual mode, the output value can be changed using the cursor keys (△ and ▽). The controller can first change back to automatic mode when the signal range violation no longer exists.

IN	**-CO- MAN**	Switch to manual mode in case of signal failure	
	oFF FAIL	Off	
	F01 FAIL	With output value Y1K1	
	F02 FAIL	With last manipulated variable value	
	-PA- MAN		
	Y1K1	Constant output	[**–10.0** ... 110.0 %]

Note: *The Y1K1 parameter can also be defined in -CO- SAFE and -CO- RE.CO functions. Refer to sections 6.5.1 and 6.7.1.*

6.2.5 -CO- CLAS: Assignment of X and WE to analog inputs

Internally, the compact controller operates with the analog input signals X and WE. The CLAS function is used to assign these signals to the analog inputs IN1 or IN2. By default, X is assigned to analog input IN2 and WE to analog input IN1.

IN	**-CO- CLAS**	Assignment of X to analog inputs
	In2 X	X = IN2
	In1 X	X = IN1
		Assignment of WE to analog inputs
	In1 WE	WE = IN1
	In2 WE	WE = IN2

6.2.6 -CO- DI.FI: Filtering of X and WE

This function enables you to determine whether X and/or WE are to be filtered.

The first-order filter (low-pass filter or Pt1 behavior) smooths the selected signals and suppresses input signal interferences of higher frequency. The time constant of the Pt1 element is defined by the TS.X parameter for the input signal X, and by TS.WE for the input signal WE.

IN	**-CO- DI.FI**	Filtering of input variable X	
	oFF X	Off	
	on X	On	
	TS/X	Time constant of X filter	[0.1 … **1.0** … 100.0 s]
		Filtering of input variable WE	
	oFF WE	Off	
	on WE	On	
	TS.WE	Time constant of WE filter	[0.1 … **1.0** … 100.0 s]

6.2.7 -CO- SQR: Root extraction of X and WE

This function performs a root extraction of the input variables and internally standardizes them between 0 to 100 %: $X' = 10 \cdot \sqrt{X}$ and $WE' = 10 \cdot \sqrt{WE}$.

The root extraction function is used for flow rate measurement by an orifice plate assembly to calculate the flow rate from a measured differential pressure.

IN	**-CO- SQR**	Root extraction of X
	oFF X	Off
	on X	On
		Root extraction of WE
	oFF WE	Off
	on WE	On

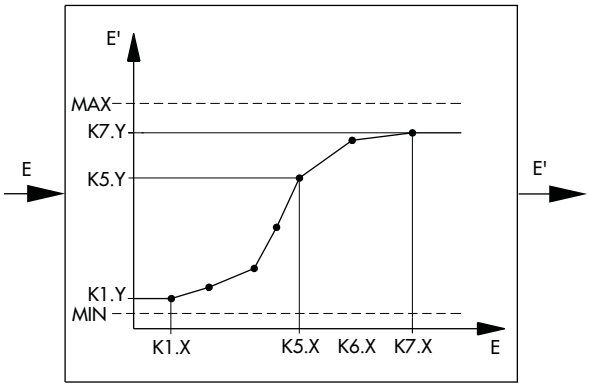
6.2.8 -CO- FUNC: Function generation of X and WE

The function generation is used to revaluate an input signal to allow further processing. This function makes it possible to adapt auxiliary, reference or equivalence variables, inherent in measurement or industrial processes, for the control circuit or to perform a linearization. This can be performed when the correlation between the input signal and the required new output

signal is known (i.e. due to scientific laws, empirical data or measured data). Examples include the correlation between steam pressure and temperature.

Seven coordinates exist for function generation. Each coordinate is defined by an input value and an output value.

- Numerical values (e.g. in °C or bar) are entered
- The parameters MIN and MAX are used to determine the measuring range of the output signal E'. If K1.Y or K7.Y do not agree with MIN and MAX, the output values for the function-generated signal, which are below or above these limits, are constantly set to K1. Y or K7.Y.
- The compact controller completes the polygonal curve by generating straight lines (Fig. 4). If you have entered an output value greater than MAX or smaller than MIN, it will be set to the value of MAX or MIN. Section 7 shows an example of function generation.



MIN	Lower range value of output signal
MAX	Upper range value of output signal
K1.Y	Output value 1
K5.Y	Output value 5
K7.Y	Output value 7
K1.X	Input value 1
K5.X	Input value 5
K6.X	Input value 6
K7.X	Input value 7
E	Signal before function generation (input signal)
E'	Signal after function generation (output signal)

Fig. 4 · Function generation

Note:

– *We recommend creating a table or to plot the curve in a Cartesian coordinate system. The seven points for function generation must be selected to be able to plot the curve properly. The controller calculates a straight line between points. Seven points must be defined even if the signal course can be plotted sufficiently with less than seven points. If necessary, enter the first points or the last points to be the same.*

– *The polygonal chain of the curve is not restricted. Polygonal curves with more than one maximum or minimum are possible. However, make sure that only one output value is assigned to an input value. Otherwise, the input signal cannot be clearly assigned to a value.*

IN	**-CO- FUNC**	Function generation of X	
	oFF X	Off	
	on X	On	
	-PA- FUNC/X		
	MIN	Lower range value of output signal	[–999.0 … **0.0** … MAX]
	MAX	Upper range value of output signal	[MIN … **100.0** … 9999]
	K1.X	Input value 1	[⩽ **IN1** … ⩾ IN1; ⩽ **IN2** … ⩾ IN2]
	K1.Y	Output value 1	[**MIN** … MAX]
	…	…	…
	K7.X	Input value 7	[⩽ **IN1** … ⩾ IN1; ⩽ **IN2** … ⩾ IN2]
	K7.Y	Output value 7	[**MIN** … MAX]
		Function generation of WE	
	oFF WE	Off	
	on WE	On	
	-PA- FUNC/WE		
	MIN	Lower range value of output signal	[–999 … **0.0** … MAX]
	MAX	Upper range value of output signal	[MIN … **100** … 9999]
	K1.X	Input value 1	[⩽ **IN1** … ⩾ IN1] ⩽ **IN2** … ⩾ IN2]
	K1.Y	Output value 2	[**MIN** … MAX]
	…	…	
	K7.X	Input value 7	[⩽ **IN1** … ⩾ IN1] ⩽ **IN2** … ⩾ IN2]
	K7.Y	Output value 7	[**MIN** … MAX]

6.3 SETP menu: Set point

This menu enables enables you to determine the functions of a set point. The compact controller has two internal set points W and W2 as well as an external set point WE.

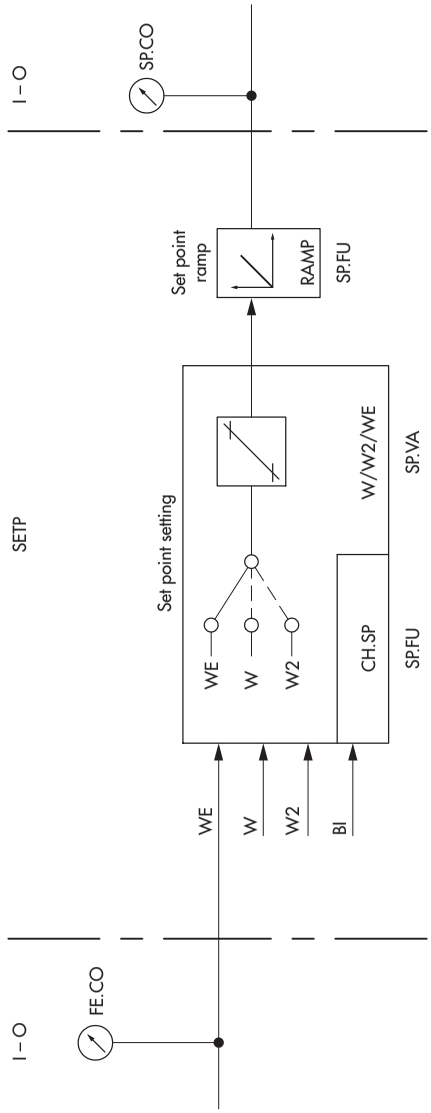


Fig. 5 · SETP menu

6.3.1 -CO- SP.VA: Set point setting

This function enables you to define which set point W2 or WE is activated. The internal set point W is always active. The set point and its measuring range can be determined in the parameter level. The measuring range (⍋WINT, ⍍WINT) must be identical to the measuring range of the controlled variable X (⍋ IN1, ⍍IN1 or ⍋IN2, ⍍IN2) or it must be identical to the output range (MIN, MAX) when function generation is active. The internal set points W and W2 can only be adjusted within the upper and lower adjustment limits (⍋WRAN, ⍍WRAN).

Function of input variable WE:

- **on WE:** WE is used as the external set point
- **F01 WE:** WE is used for external position feedback with three-step output (see section 6.5.10). In this setting, WE is not displayed in the operating level. The reading is shown only in the I-O menu, (see section 6.9.3).
- **F02 WE:** WE is used for feedforward control (see section 6.4.7). In this setting, WE is not displayed in the operating level. The reading is only shown in the I-O menu, (see section 6.9.3).

SETP	**-CO- SP.VA**	Internal set point W	
	on W	On	
	-PA- SP.VA/W		
	W	Internal set point	[⍋ WRAN … **0.0** … ⍍ WRAN]
	⍋ WINT	Lower measuring range value W/W2	[–999 … **0.0** … ⍍ WINT]
	⍍ WINT	Upper measuring range value W/W2	[⍋ WINT … **100.0** … 9999]
	⍋ WRAN	Lower adjustment limit W/W2	[⍋ WINT … **0.0**… ⍍ WRAN]
	⍍ WRAN	Upper adjustment limit W/W2	[⍋ WRAN … **100.0** … ⍍ WINT]
		Internal set point W2	
	oFF W2	Off	
	on W2	On	
	-PA- SP.VA/W2		
	W2	Internal set point 2	[⍋ WRAN … **0.0** … ⍍ WRAN]
		Input variable WE	

oFF WE	Off
on WE	External set point WE
F01 WE	Input for external feedback with three-step output
F02 WE	Input for feedforward control

6.3.2 -CO- SP.FU: Set point functions

6.3.2.1 -CO- SP.FU/RAMP Set point ramp

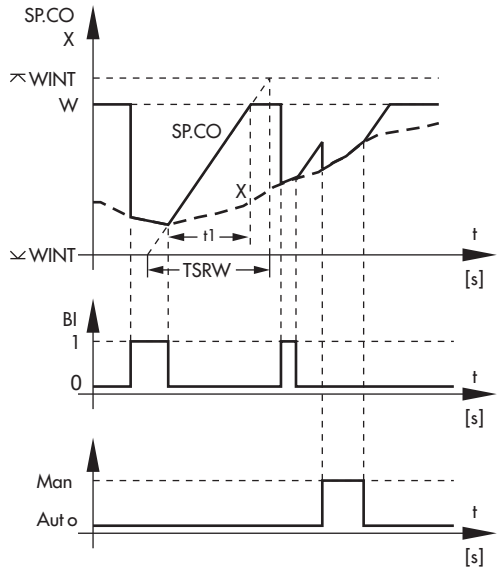
A set point ramp is particularly suited for closed-loop controlled systems which do not tolerate rapidly changing set points. The ramped transition from one set point to another helps to avoid hunting. In the set point ramp, the set point at the comparator SP.CO runs according to the adjusted running time at a constant rate from the initial set point to the target set point. Depending on how the -CO- SP.FU function is configured, the ramp starts either using the current value of the controlled variable X at the comparator, the initial value WIRA or another set point.

The running time of the set point ramp is determined for the entire measuring range (⧩ WINT to ⧪ WINT) by the TSRW parameter. When the set point changes from a value W to a new value W2, the actual running time of the set point ramp is the time t1 , as illustrated in Figs. 7 and 8.

The value for the TSRW parameter can be calculated as follows:

$$TSRW = t1 \cdot \frac{|⧪\,WINT - ⧩\,WINT|}{|W2 - W|}$$

- **F01 RAMP – Start set point ramp with the controlled variable at the comparator:** This ramp function is started by a binary input. An active binary input causes the set point at comparator SP.CO to adopt the same value as the current value of the controlled variable at comparator X. A signal change at the binary input from '1' (active) to '0' (inactive) starts the ramp and the set point runs until it reaches the target set point (internal or external set point). After reaching the target set point, the ramp stops. After this, the set point at comparator SP.CO follows the target set point (e.g. W) without delay.
  If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point adopts the same value as the controlled variable X. After switching back to automatic mode, the ramp continues to run again until reaching the target set point. If the binary input is activated again while the ramp is running, the set point at comparator SP.CO returns to the current value at comparator X (retriggering).
  If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the set point at comparator SP.CO adopts the same value as at the comparator when the binary input is active and the target set point when the binary input in not active.



WINT	Lower measuring range value
WINT	Upper measuring range value
TSRW	Running time of the set point ramp
t1	Actual running time of the set point ramp

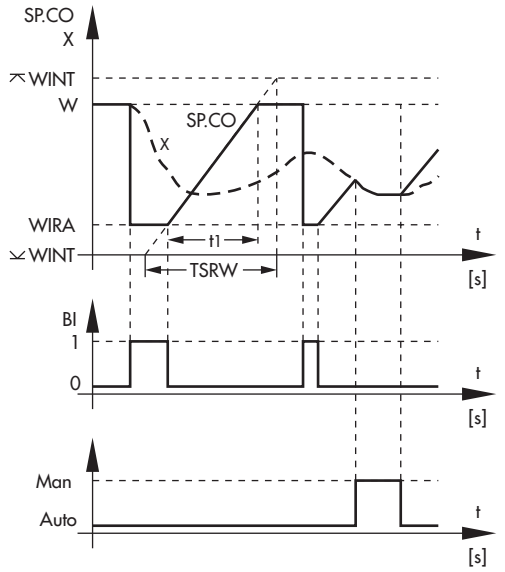
Fig. 6 · Start set point ramp by binary input, SP.CO = X

F02 RAMP – Start set point ramp with initial set point: This ramp function is started by the binary input. An active binary input causes the set point at comparator SP.CO to be set to the entered initial set point WIRA. A signal change at the binary input from '1' (active) to '0' (inactive) starts the ramp and the set point runs until it reaches the target set point (internal or external set point). After reaching the target set point, the ramp stops. After this, the set point at comparator SP.CO follows the target set point (e.g. W) without delay.

If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point at comparator SP.CO adopts again the same value as the controlled variable X.

After switching back to automatic mode, the ramp continues to run again until reaching the target set point. If the binary input is activated again while the ramp is running, the set point at comparator SP.CO returns to the current value at comparator X (retriggering).

If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the set point at comparator SP.CO adopts the start set point WIRA when the binary input is active and the target set point when the binary input in not active.



WINT	Lower measuring range value
WINT	Upper measuring range value
TSRW	Running time of the set point ramp
WIRA	Initial value
t1	Actual running time of the set point ramp

Fig. 7 · Start set point ramp by binary input, SP.CO = WIRA

F03 RAMP – Set point continuously active (without start condition): The ramp function in this setting is continuously active. Every change of the set point causes a ramped change of the set point at comparator SP.CO even after switchover between set points. The diagram shows the set point ramp (SP.CO) during a switchover between set points W and W2 (additional settings: -CO- SP.VA = on W2 and -CO- SP.FU = F01 CH.SP) initiated by the binary input.

If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point at comparator SP.CO adopts the current value at comparator X. After switching back to automatic mode, the ramp continues to run again until reaching the target set point. If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the set point at comparator SP.CO adopts the target set point.

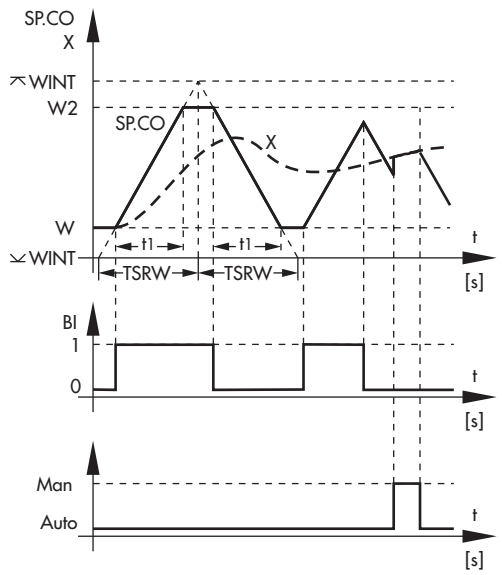


Fig. 8 · Set point continuously active

6.3.2.2 -CO- SP.FU/CH.SP Set point switchover by binary input

This functions enables you to determine the conditions for switching between the internal and external set point.

- **oFF CH.SP:** No set point switchover
- **F01 CH.SP:** Switchover between active internal and external set points initiated by binary input BI (W/W2 to WE)
  WE is active when the binary input is active.
- **F02 CH.SP:** Switchover between the internal set points initiated by binary input BI (W to W2).
  W2 is active when the binary input is active.
  W is active when the binary input is not active.
  The -CO- SP.VA function must not be set to 'on WE'. If the set point W2 is activated over the keypad while the binary input is inactive, it is not possible to switchover to the set point W using the binary input.

Note: *Several functions can be assigned to the binary input. See page 32.*

SETP	**-CO- SP.FU**	Set point ramp	
	oFF RAMP	Off	
	F01 RAMP	Started with actual value (process variable) by binary input BI1	
	F02 RAMP	Started with WIRA by binary input BI1	
	F03 RAMP	Without start condition	
	-PA- SP.FU/RAMP		
	TSRW	Transit (running) time	[1 … **10** … 9999 s]
	WIRA	Initial value	[⍊WINT … **0.0** … ⍓WINT]
		Set point W(W2)/WE switchover	
	oFF CH.SP	Off	
	F01 CH.SP	W(W2)/WE by binary input BI1	
	F02 CH.SP	W/W2 by binary input BI1	

6.4 CNTR menu: Controller functions

This menu enables enables you to determine the control behavior. In particular, you can determine whether the controller is to function with P, PI, PD, PID or P²I action. Furthermore, you can configure the feedforward control and additional control functions in this menu.

6.4.1 -CO- C.PID: Control algorithm

In this function, the control algorithm and control parameters are configured. The controller is set to PI action by default.

- The **proportional-action coefficient KP** acts as gain on the P, I and D terms.
  Increasing the proportional-action coefficient makes the output amplitude increase in a P controller.
- The **reset** (integral) **time TN** is the parameter of the I term. TN is the time it takes for the integral term during a step response in a PI controller to produce the same change in output as the P term.
  Increasing the reset time TN causes a reduction in the rate of change in the output when the error is constant.
- The **derivative-action time TV** is the parameter of the D term. The derivative-action time TV is the time it takes the rise response of a PD controller to reach a certain output earlier than it would with just its P term.
  Increasing the derivative-action time TV causes an increase in output amplitude when the error rate of change is constant. After ramped error changes, a larger derivative-action time TV causes the D term to continue to have a longer effect.
- The **derivative-action gain TVK1** is a gain factor for the derivative term.
- The **operating point Y.PRE** of the P or PD controller determines the output value which is fed to the controlled system when the process value is the same as the set point.
- The **dead band error DZXD** allows you to define the range of the signal error. Within this range, the effective error signal is zero and the control signal does not change. The dead band can be used to calm the control loop by suppressing a frequently change of the control valve at the operating point.
- **Limiting the error signal**
  Using the ⩡DZXD and ⩠DZXD parameters, the effective error signal can be limited for calculating the control signal.
  The ⩡DZXD parameter is used to define the lower limit of the negative error signal, while the ⩠DZXD parameter is used to define the top limit of the positive error signal.

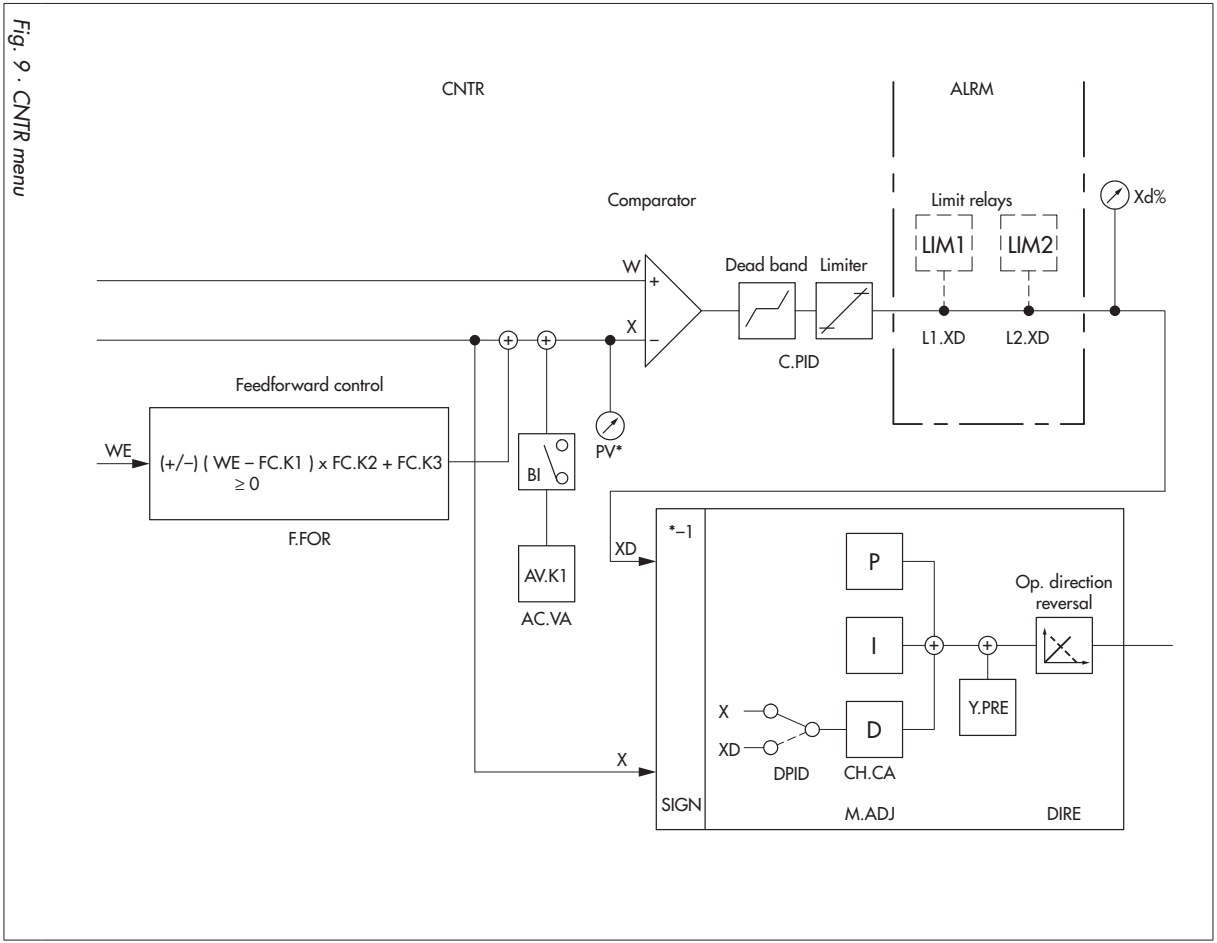


Fig. 9 · CNTR menu

Assignment between control parameters and control behavior					
	P	PI	PD	PID	P²I
KP	•	•	•	•	•
TN	–	•	–	•	•
TV	–	–	•	•	–
TVK1	–	–	•	•	–
Y.PRE	•	•	•	•	•
DZXD	•	•	•	•	•
⩡ DZXD	•	•	•	•	•
⩠ DZXD	•	•	•	•	•

CNTR	**-CO- C.PID**	Control algorithm	
	P CP.YP	P	
	PI CP.YP	PI	
	Pd CP.YP	PD	
	PId CP.YP	PID	
	PPI CP.YP	P²I	
	-PA- C.PID		
	KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]
	TN	Reset time	[1 … **120** … 9999 s]
	TV	Derivative-action time	[1 … **10** … 9999 s]
	TVK1	Derivative-action gain	[0.10 … **1.00** … 10.00]
	Y.PRE	Operating point	[–10.0 … **0.0** … 110 %]
	DZXD	Dead band error XD	[**0.0** … 110.0 %]
	⩡ DZXD	Minimum effective error XD	[**–110.0 %** … ⩠ DZXD]
	⩠ DZXD	Maximum effective error XD	[⩡ DZXD … **110.0 %**]

Note: *The control parameters KP, TN, TV and Y.PRE can also be set in the PAR menu.*

6.4.2 -CO- SIGN: Inversion of error XD

This function enables you to reverse the operating direction of the error signal. The inversion causes an increasing error signal to be changed into a decreasing error signal or vice versa. As a result, the control signal's operating direction changes, too.

CNTR	**-CO- SIGN**	Inversion error XD
	dir.d XD	Not inverted
	in.d XD	Inverted

Note: *The adjusted operating direction can also be changed in -CO- DIRE (see section 6.4.6).*

6.4.3 -CO- D.PID: Assignment of the derivative-action component to the control output

In PD and PID controllers, the error signal or the controlled variable can optionally be assigned as the source for the derivative term.

- **F01 DP.YP:** Source for the derivative-action component is the error signal XD. A change in the controlled variable and set point has an effect on the manipulated variable through the derivative-action component.
- **F02 DP.YP:** Source for the derivative-action component is the controlled variable X. A change in the controlled variable has an effect on the manipulated variable through the derivative-action component. A change in the set point is not taken into account by the derivative-action component.

CNTR	**-CO- D.PID**	Assignment of D element to the control output
	F01 DP.YP	To error
	F02 DP.YP	To controlled variable

6.4.4 -CO- CH.CA: Control mode selection P(D)/PI(D)

For PI and PID controllers, the control mode selection enables the controller to be operated in various operating states with or without the integral term. This function allows the integral term to be automatically activated by the error signal or by the set point. It can only be selected when a PI or PID behavior has been configured. Refer to section 6.4.1.

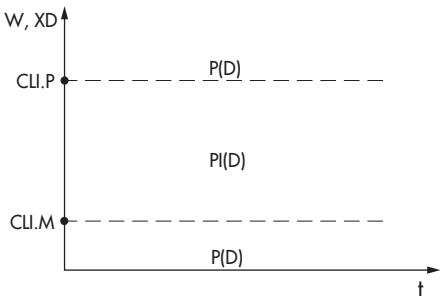
The P(D)/PI(D) control mode selection is preferably to be used when the set point is to start up as quickly as possible and without overshooting, while no offset is to exist. This is required espe-

cially for control of discontinuous processes, such as during batch operation of an autoclave, an open-steam vulcanizer or a furnace.

With control mode selection, the controller works as a P (or PD) or the PI (or PID) controller depending on the error signal or the set point. Outside a definable range of the error signal or set point, the controller works as a P or PD controller. While, within this range, the integral term is activated and the controller works as a PI or PID controller. The range is defined by the CLI.P and CLI.M parameters. Fig. 10 illustrates this behavior.

Note for F01 CC.P setting: *If the controller changes from manual to automatic mode while the error signal is outside the defined range, the operating point is determined by the last manual output value. The operating point is effective until the error signal returns to the range. The operating point of PI(D) action is determined there. If the error signal moves outside the range again, the integral term is saved and the last output value is set as the operating point. If the controller changes from automatic to manual mode, the operating point required for the plant must be reset again before returning to the automatic mode. The operating point is only saved temporarily (Y.PRE parameter does not have any effect). After power failure, the operating point must be reset in manual mode.*

CNTR	**-CO- CH.CA**	Control mode selection P(D)/PI(D)	
	oFF CC.P	Off	
	F01 CC.P	By error	
	F02 CC.P	By set point	
	-PA- CH.CA		
	CLI.P	Maximum limit for PI(D) control	[–110.0 … **10.0** … 110.0 %]
	CLI.M	Minimum limit for PI(D) control	[–110.0 … **–10.0** … 110.0 %]



W	Set point
XD	Error signal
CLI.P	Maximum limit for range of PI(D) control
CLI.M	Minimum limit for range of PI(D) control

Fig. 10 · Control mode changeover

6.4.5 -CO- M.ADJ: Operating point preset by manual operation for YPID

This function enables you to define an operating point in manual mode. In automatic mode, the defined operating point is added to the calculated manipulated variable.

The defined operating point remains effective until either the operating point setting in manual mode is deactivated by selecting oFF MA.YP, or until a new operating point is set in manual mode. If the operating point setting in manual mode is deactivated, the manipulated variable determined in manual mode assumes the calculated value within approx. two seconds.

After a power supply failure, the operating point in manual mode must be reset.

CNTR	**-CO- M.ADJ**	Operating point preset by manual operation for YPID
	oFF MA.YP	Off
	on MA.YP	On

6.4.6 -CO- DIRE: Operating direction of manipulated variable

The operating direction of the manipulated variable can be adapted to the operating direction of the controlled system or control valve. The manipulated variable can either act directly or inversely to the error signal (signal error = set point – process variable).

Note: *The operating direction can also be inverted in -CO- SIGN. Refer to section 6.4.2.*

CNTR	**-CO- DIRE**	Operating direction manipulated variable
	dir.d DI.AC	Direct
	in.d DI.AC	Inverted

6.4.7 -CO- F.FOR: Feedforward control

The input variable WE can be used for feedforward control (see section 6.3.1).

The disturbance signal can be valuated by parameters according to the following formula and linked (addition). This disturbance signal is added to the controlled variable.

$\pm(WE - FC.K1) \cdot FC.K2 + FC.K3$, with $(WE - FC.K1) \geq 0$

FC.K1, FC.K2 and FC.K3 are constants that can be defined in the parameter level. The plus or minus sign of the formula is determined in the -CO- F.FOR function. Refer to section 6.4.7.

The D -CO- F.FOR function can be used for a **measured value correction**.
For example, if a Pt 100 sensor is connected in a two-wire circuit and has a higher temperature

reading due to the lead resistance, the reading error can be compensated by a negative correction value.

Example: The temperature reading is 2 °C higher than the actual temperature (measuring range 0 to 100 °C). The reading error is corrected by the following setting:

- Function: -CO- F.FOR, setting POS FECO
- Parameter -PA-: FC.K1 = 0.0 %, FC.K2 = 0.0, FC.K3 = –2.0 %

Note: *A measured value can also be corrected by performing a function generation on the input variable (-CO- FUNC→ section 6.2.8) or by calibrating the input (-CO- ADJ→ section 6.9.5).*

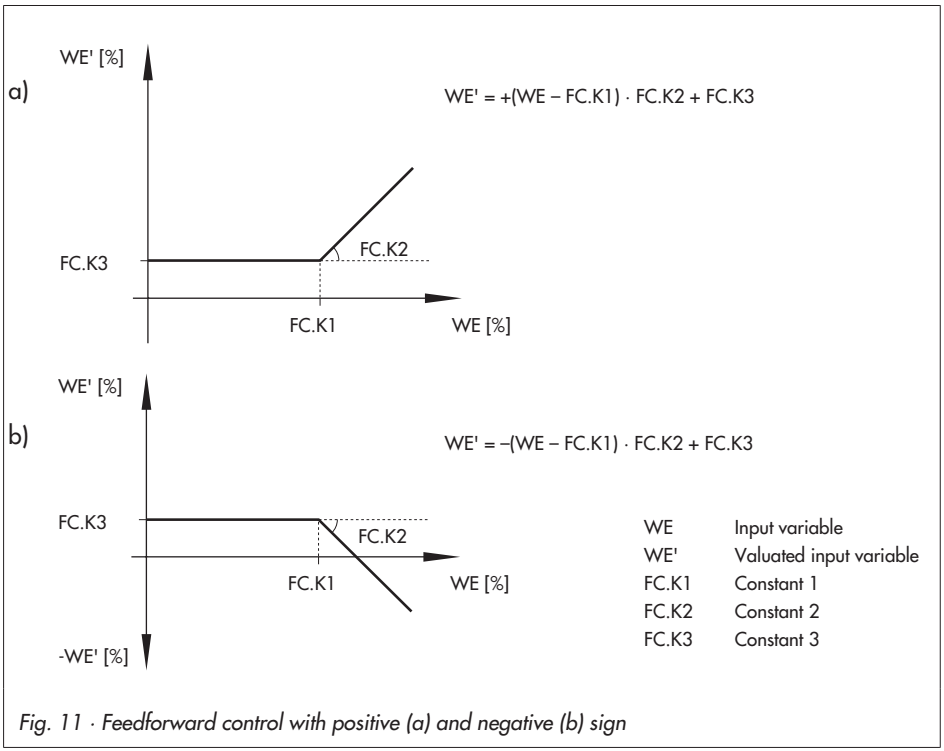


Fig. 11 · Feedforward control with positive (a) and negative (b) sign

CNTR	**-CO- F.FOR**	Feedforward control	
	oFF FECO	Off	
	P0S FECO	With positive sign	
	nE6 FECO	With negative sign	
	FC.K1	Constant 1	[**0.0** … 110.0 %]*
	FC.K2	Constant 2	[0.0 … **1.0** … 100.0]
	FC.K3	Constant 3	[–110.0 … **0.00** … 110.0 %]*) **)

* Percent based on the measuring range of the controlled variable X

** The FC.K3 parameter can be adjusted in the range between –9.99 and 99.99 with two decimal places.

6.4.8 -CO- AC.VA: Increase/decrease actual value (process variable)

This function is used to link (add) the input signal X to the constant AV.K1 when the binary input is active. The new process variable is used for closed-loop control and shown on the display (top row). When the binary input is deactivated, the input signal X is used again for closed-loop control.

CNTR	**-CO- AC.VA**	Increase/decrease actual value	
	oFF IN.DE	Off	
	bi1 IN.DE	By binary input BI	
	AV.K1	Constant in percent (±process variable)	[–110.0 … **0.0** … 110.0 %]

Note: *Several functions can be assigned to the binary input.* *See page 32.*

6.5 OUT menu: Output functions

The output functions of the compact controller are determined in this menu.

6.5.1 -CO- SAFE: Activate constant output value

A defined constant output value Y1K1 can be issued at the control output Y in automatic mode initiated by the binary input. The constant output value is activated when the binary input is active. When the binary input is deactivated, the closed-loop control continues starting from this constant output value. This function can be used to enable control.

The constant output value cannot be activated in manual mode.

OUT	**-CO- SAFE**	Activate constant output value	
	oFF SA.VA	Off	
	bi1 SA.VA	By binary input BI1	
	-PA- SAFE		
	Y1K1	Constant output value	[–10.0 … **0.0** … 110.0 %]

Note: *Several functions can be assigned to the binary input.* *See page 32.*

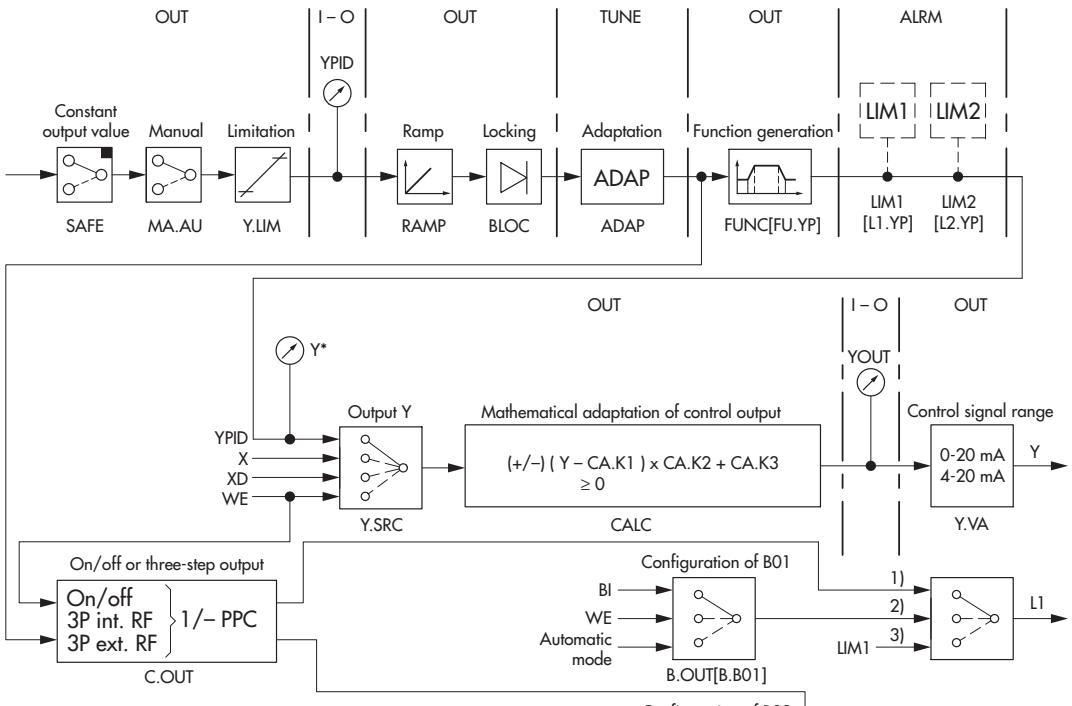
6.5.2 -CO- MA.AU: Manual/automatic switchover

This function causes the controller to switch to manual mode when the binary input is activated. During which, the key is locked. The controller returns to automatic mode when the binary input is deactivated.

The controller can be changed to the manual mode and back into automatic mode using the key when the binary input is deactivated.

OUT	**-CO- MA.AU**	Manual/automatic switchover	
	oFF CH.MA	Off	
	bi1 CH.MA	By binary input BI	

Note: *Several functions can be assigned to the binary input.* *See page 32.*



* In automatc mode: Y reading in the operating level

** In manual mode: Y reading in the operating level

1) Assignment to on/off output or three-step output

2) Assignment to binary output BO1, BO2

3) Assignment to limit relay L1, L2

Fig. 12 · OUT menu

6.5.3 -CO- Y.LIM: Control signal limitation YPID

Control signal limitation is always active. The parameters for the minimum and maximum manipulated variable can be determined in this function.

A 4 to 20 mA control signal is assigned as follows: 0 % = 4 mA and 100 % = 20 mA.

OUT	**-CO- Y.LIM**	Output signal limitation YPID	
	on LI.YP	On	
	-PA- Y.LIM		
	$\underline{Y}$	Minimum manipulated variable	[–10.0 … **0.0** … 110. %]
	$\overline{Y}$	Maximum manipulated variable	[–10.0 … **100.0** … 110.0 %]

6.5.4 -CO- RAMP: Output ramp/output rate limitation

F01 RA.YP and F02 RA.YP – Output ramp

The output ramp is the change of the output at a constant rate. The TSRA parameter determines the running time for the output ramp and the rate as a result. This parameter is based on a change of the output by 100 % (Fig. 13). When the binary input is activated, the control output is set to the initial value. When the binary input is deactivated, the output ramp starts.

- In the F01 RA.YP setting, the initial value is fixed at –10.0 %.
- Select the F02 RA.YP setting to enter the initial value as required using the Y1RA parameter.

The output ramp is stopped in manual mode and upon restart after a power failure.

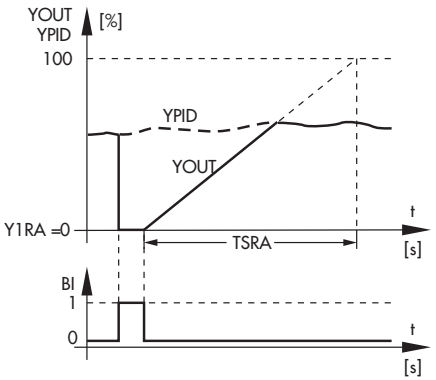
F03 RA.YP, F04 RA.YP and F05 RA.YP – Output rate limitation

The rate of output change can be limited for a decreasing and/or an increasing output. In the limited direction(s), the manipulated variable changes only as fast as the TSRA parameter allows it to. This parameter is based on a change of the output by 100 %. If the rate of output change is slower than the defined rate of changes, limitation will not be effective.

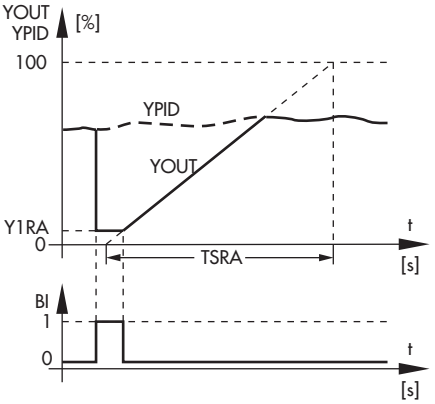
Fig. 14 illustrates the effect of the described function. The rate of change for the output v_y is calculated as follows:

$$v_y = \frac{100\ \%}{TSRA}$$

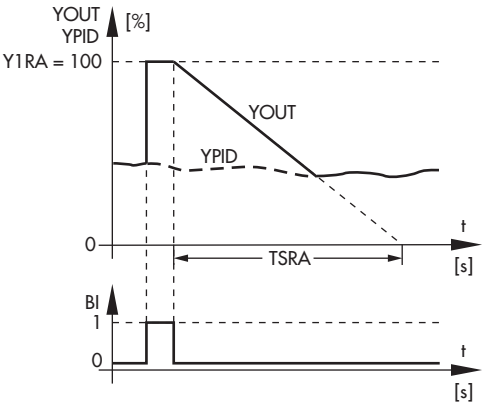
Ramp increasing
Initial value Y1RA = 0 %



Ramp increasing
0 % < Initial value Y1RA < 100 %



Ramp decreasing
Initial value Y1RA = 100 %



BI	Binary input
TSRA	Running time
YOUT	Analog output
YPID	Internal manipulated variable
Y1RA	Initial value

Fig. 13 · Output ramp: ***F02 RA.YP with ramp increasing/descreasing, started with Y1RA by BI***

OUT	**-CO- RAMP**	Output ramp/output rate limitation	
	oFF RA.YP	Off	
	F01 RA.YP	Output ramp, started with –10 % by binary input BI1	
	F02 RA.YP	Output ramp, started with Y1RA by binary input BI1	
	F03 RA.YP	Limitation when manipulated variable decreases and increases	
	F04 RA.YP	Limitation when manipulated variable increases	
	F05 RA.YP	Limitation when manipulated variable decreases	
	-PA- RAMP/RA.YP		
	TSRA	Transit (running) time	[**1** … 9999 s]
	Y1RA	Initial value	[–10.0 … **0.0** … 110.0 %]

Note: *Several functions can be assigned to the binary input.* *See page 32.*

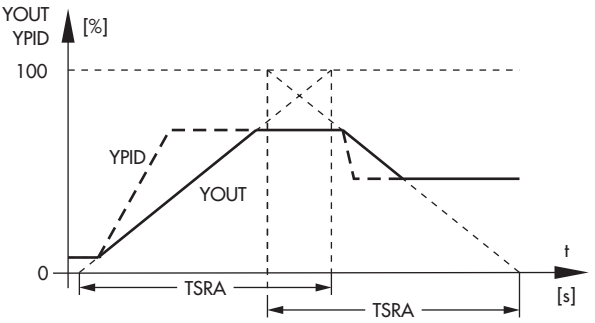
6.5.5 -CO- BLOC: Locking manipulated variable YPID

This function locks the control signal when the binary input BI is activated. As a result, the current value of the output at the controller output remains unchanged as long as the binary input is active. When it is deactivated, the locking of the output signal is cancelled, and the controller continues to work with the last output value.

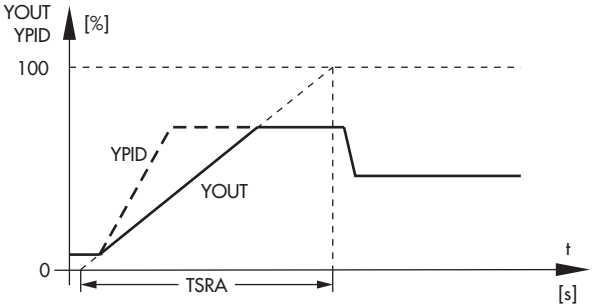
OUT	**-CO- BLOC**	Locking manipulated variable YPID
	oFF BL.YP	Off
	on BL.YP	By binary input BI1

Note: *Several functions can be assigned to the binary input.* *See page 32.*

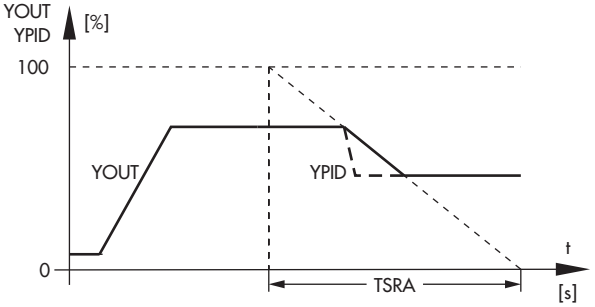
F03 RA.YP setting
Limitation when manipulated variable decreases and increases



F04 RA.YP setting
Limitation when manipulated variable increases



F05 RA.YP setting
Limitation when manipulated variable decreases



YPID	Internal manipulated variable
YOUT	Analog output
TSRA	Running time

Fig. 14 · Output rate limitation

6.5.6 -CO- FUNC: Function generation of manipulated variable

A function generation can be performed on the manipulated variable Y in the same way as for the input variables X and WE. Function generation is described in detail in section 6.2.8. The input and output values are entered in percent.

OUT	**-CO- FUNC**	Function generation of manipulated variable	
	oFF FU.YP	Off	
	on FU.YP	On	
	-PA- FUNC/FU.YP		
	K1.X	Input value 1	[–10.0 … **0.0** … 110.0 %]
	K1.Y	Output value 1	[–10.0 … **0.0** … 110.0 %]
	…	…	…
	K7.X	Input value 7	[–10.0 … **0.0** … 110.0 %]
	K7.Y	Output value 7	[–10.0 … **0.0** … 110.0 %]

6.5.7 -CO- Y.VA: Signal range for analog output Y

This function allows the signal range for the analog output to be determined.

OUT	**-CO- Y.VA**	Signal range for analog output Y
	oFF Y	Off
	0–20 mA	0 to 20 mA
	4–20 mA	4 to 20 mA
	0–10 V	0 to 10 V
	2–10 V	2 to 10 V

6.5.8 -CO- Y.SRC: Source for analog output Y

This functions allows you to determine the source for the analog output Y. The manipulated variable YPID is assigned to the analog output by default. Optionally, the input variables X, WE or the error signal XD can also be assigned as the source.

The input variables X and WE are issued based on the input measuring range, e.g. for an input measuring range 0 to 200 °C:
X = 0 °C ⇒ Y = 0 % (e.g. 4 mA) and X = 200 °C ⇒ Y = 100 % (e.g. 20 mA)

The error signal is issued on the range –100 to +100 %, i.e.
XD = –100 % ⇒ Y = 0 % (e.g. 4 mA) and X = +100 % ⇒ Y = 100 % (e.g. 20 mA)

OUT	**-CO- Y.SRC**	Source for analog output Y
	on Y.PID	Output YPID
	on Y.X	Input X
	on Y.WE	Input WE
	on Y.XD	Error XD

6.5.9 -CO- CALC: Mathematical adaptation of analog output Y

This function causes the continuous-action output to be adapted according the following mathematical formula:

$$YOUT = \pm(Y - CA.K1) \cdot CA.K2 + CA.K3$$

OUT	**-CO- CALC**	Mathematical adaptation of analog output Y	
	oFF CA.Y	Off (no output signal)	
	on CA.Y	Without condition	
	PO5 CA.Y	With positive sign	
	nE6 CA.Y	With negative sign	
	-PA- CALC/CA.Y		
	CA.K1	Constant 1	[**0.0** ... 100.0 %]
	CA.K2	Constant 2	[0.0 ... **1.0** ... 10.0]
	CA.K3	Constant 3	[–10.0 ... **0.0** ... 110.0 %]

6.5.10 -CO- C.OUT: On/off output or three-step output

The on/off output or three-step output is configured by this function.

- **on 2.STP – On/off output to monitor limits of the manipulated variable**
  The on/off output Y+ has an effect on the relay BO1. This output can assume the ON and OFF states and can be used to control electric heating (ovens), for example. This version of the on/off output monitors the manipulated variable YPID for a violation of the lower limit TZ. The activating point is determined by the limit TZ and the deactivating point is determineed by the hysteresis XSDY. If the relay BO1 is activated, + appears on the display.
  In manual mode, the on/off output is inactive and the relay BO1 can be actuated by pressing the △ key.
  Refer to section 4 for the electrical wiring.

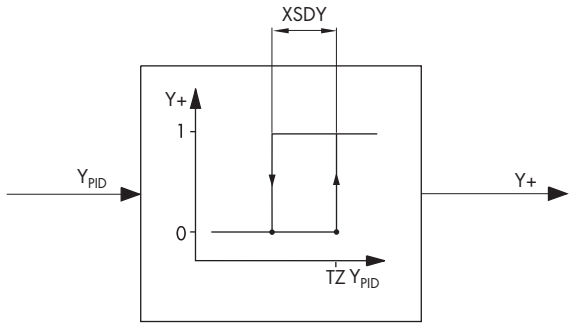


Fig. 15 · On/off output

Note:

- *Two different configurations of the on/off output are possible:*
  (1) on/off output with pulse pause modulation (PPM), (see page 67)
  (2) on/off output to monitor the limit of error signal XD or controlled variable X using limit relays L1 and L2, (see page 74)
- *If the relay BO1 is configured with the 'on 2.STP' setting to be used as an on/off output, the relay BO2 is available to issue limit alarms or status messages.*

OUT	**-CO- C.OUT**	On/off output or three-step output	
	on 2.STP	On/off output	
	-PA- C.OUT/2.STP		
	XSDY	Hysteresis	[0.10 … **0.50 %** … TZ]
	TZ	Dead band	[XSDY … **2.00** … 100.0 %]

i.Fb 3.STP – Three-step output with internal position feedback

The three-step output is used to drive an electric actuator or any other equipment with integral control action using two relays.
The relay BO1 moves the actuator in the '+' direction (e.g. the actuator stem retracts/the valve opens) and the relay BO2 moves the actuator in the '–' direction (e.g. the actuator stem extends/the valve closes). If both relays are inactive, the actuator stops moving.
For the three-step output with internal feedback, the position of the actuator is calculated from the entered **transit time TY** (transit time of the actuator) and the internal feedback of the positioning pulses. Please note that the actual position of the actuator may differ from the calculated position.

The three-step output has two pairs of switching points Y+ and Y–. Each pair consists of a switch-on point and a switch-off point.
The **hysteresis XSDY** determines the distance between the switch-on point and switch-off point. The smaller XSDY is defined, the shorter the positioning pulses and the more switching there is. Note that the hysteresis must always be smaller than TZ/2.
The **dead band TZ** determines the distance between the positioning pulses Y+ and Y–. The larger TZ is defined, the longer the switchover between Y+ and Y– takes.
A comparator calculates the difference from the manipulated variable YPID (target position) and the feedback signal Y' (calculated actual position). Depending on the difference YPID – Y', the position pulses are generated as follows:
– If the difference is greater than TZ/2, the pulse Y+ activates the relay BO1.
– If the difference is greater than TZ/2, the pulse Y– activates the relay BO2.
– If the difference is smaller than the amount TZ/2 – XSDY, both relays are deactivated.

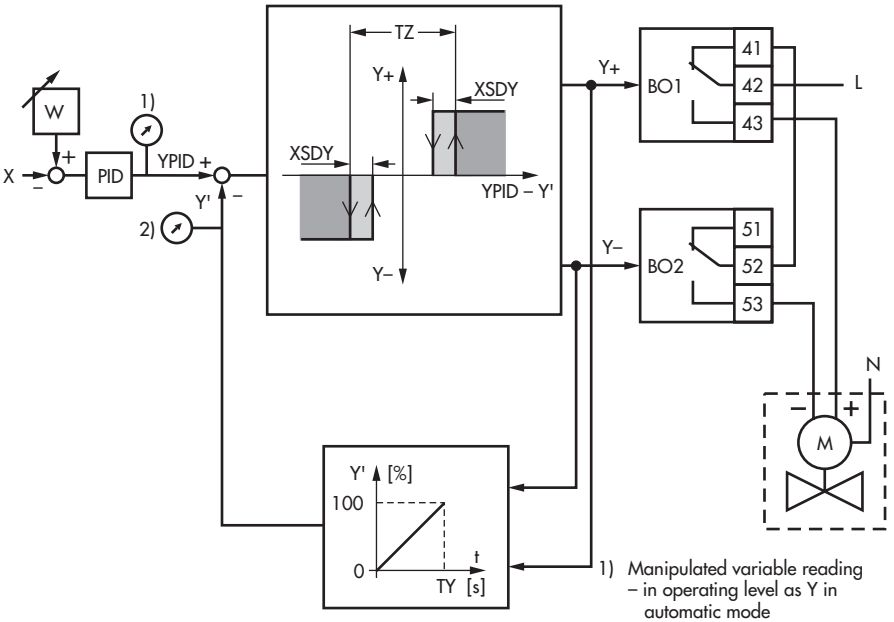


Fig. 16 · Three-step output with internal feedback

– If the manipulated variable YPID is equal or greater than 100 %, the pulse Y+ causes the relay BO1 to be activated constantly.
– If the manipulated variable YPID is equal or smaller than 0 %, the pulse Y– causes the relay BO1 to be activated constantly.

In manual mode, the relays are not controlled over the three-step output. The relay BO1 BO1 (Y+) can be actuated by pressing the △ key and the relay BO2 (Y–) by the ▽ key in manual mode.

Note on control signal limitation O- Y.LIM (see section 6.5.3): *The ⩡Y parameter must not be set to be greater than 0.0 % and the ⩠Y parameter must not be set to be smaller than 100.0 %. This ensures that the three-step output can bring the actuator into the end positions using the constant signals Y+ and Y– .*

OUT	**-CO- C.OUT**	On/off output or three-step output	
	i.Fb 3.STP	Three-step output with internal feedback	
	-PA- C.OUT/3.STP		
	XSDY	Hysteresis	[0.10 … **0.50** % … TZ]
	TZ	Dead band	[XSDY … **2.00** … 100.0 %]
	TY	Transit time	[1 … **60** … 9999 s]

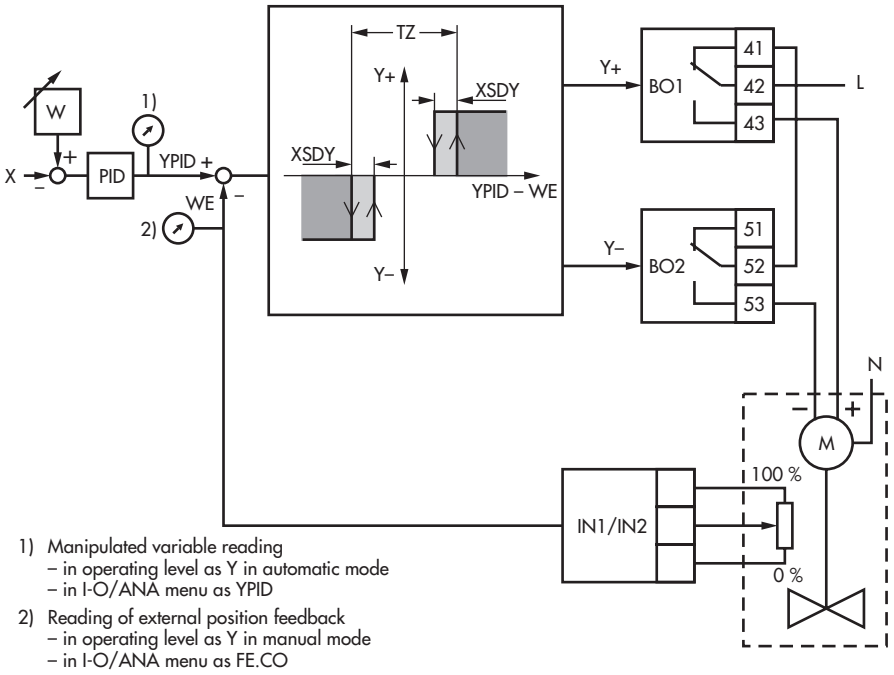
E.Fb 3.STP – Three-step output with external position feedback

The three-step output is used to drive an electric actuator or any other equipment with integral control action using two relays.
The relay BO1 moves the actuator in the '+' direction (e.g. the actuator stem retracts/the valve opens) and the relay BO2 moves the actuator in the '–' direction (e.g. the actuator stem extends/the valve closes). If both relays are inactive, the actuator stops moving.
For the three-step output with external position feedback, the position of the actuator is fed back over the input variable WE, for example with a potentiometer.
The **hysteresis XSDY** determines the distance between the switch-on point and switch-off point. The smaller XSDY is defined, the shorter the positioning pulses and the more switching there is. Note that the hysteresis must always be smaller than TZ/2.
The **dead band TZ** determines the distance between the positioning pulses Y+ and Y–. The larger TZ is defined, the longer the switchover between Y+ and Y– takes.
A comparator calculates the difference from the manipulated variable YPID (target position) and the feedback signal WE (actual position). Depending on the difference YPID – WE, the position pulses are generated as follows:
– If the difference is greater than TZ/2, the pulse Y+ activates the relay BO1.
– If the difference is greater than TZ/2, the pulse Y– activates the relay BO2.

– If the difference is smaller than the amount TZ/2 – XSDY, both relays are deactivated.

In manual mode, the relays are not controlled over the three-step output. The relay BO1 BO1 (Y+) can be actuated by pressing the △ key and the relay BO2 (Y–) by the ▽ key in manual mode.
The input variable WE must be configured for position feedback.

Example: position feedback with a potentiometer at input IN2
– Configure input signal for analog input IN2:
IN menu, -CO- IN2 function, setting 0 – 1 kOHM (-> section 6.2.2).
– Assign the input variable WE to the analog input IN2:
IN menu, -CO- CLAS function, setting In2 WE (-> section 6.2.5).
– Assign the input variable WE to the external position feedback:
SETP menu, -CO- SP.VA function, setting F01 WE (-> section 6.3.1).



1) Manipulated variable reading
– in operating level as Y in automatic mode
– in I-O/ANA menu as YPID
2) Reading of external position feedback
– in operating level as Y in manual mode
– in I-O/ANA menu as FE.CO

Fig.17 · Three-step output with external feedback

Note: *The target position of the actuator can be limited by the -CO- Y.LIM function using the ⩡Y and ⩠Y parameters (travel limitation).*

OUT	**-CO- C.OUT**	On/off output or three-step output	
	E.Fb 3.STP	Three-step output with external feedback	
	-PA- C.OUT/3.STP		
	XSDY	Hysteresis	[0.10 … **0.50** % … TZ]
	TZ	Dead band	[XSDY … **2.00** … 100.0 %]

PP 2.STP – On/off output with pulse pause modulation (PPM)

The on/off output with pulse pause modulation (PPM) changes the continuous-action YPID signal into a pulse sequence whose pulse pause ratio varies depending on the value of YPID (Fig. 18). The on/off output can be used to control electric heating (ovens), for example. The duty cycle TE of the on/off signal Y+ is calculated as follows:

$$TE = \frac{(Y\,[\%] - TZ\,[\%]) \cdot KPL1}{100\,[\%]} \cdot TYL1\ [s]$$

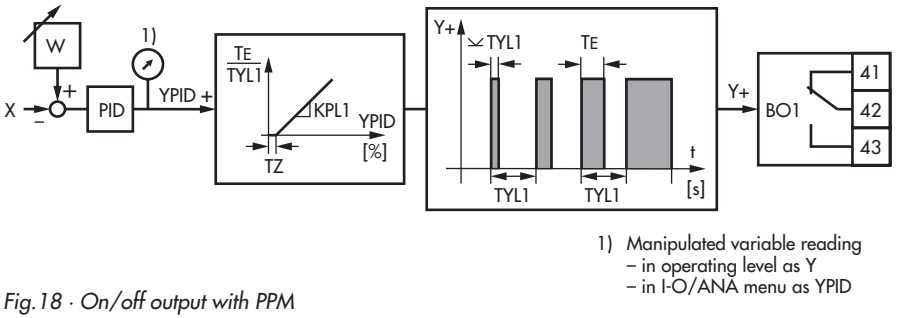
The TYL1 parameter is the cycle duration and the maximum duty cycle at the same time. KPL1 is a gain factor.

The ⩡ TYL1 parameter specifies the minimum duty cycle of the on/off signal Y+. Due to the hardware, the minimum duty cycle is at least 0.3 seconds.

When the TYL1, KPL1 and ⩡ TYL1 parameters are suitably chosen, the on/off output with PPM provides a good compromise between small fluctuations in the controlled variable (high switching frequency) and high service life of the final control element (low switching frequency). The on/off output has a direct effect on the relay BO1 and a reverse effect on relay BO2.

In manual mode, the on/off output is actuated by the manual output value and the relay is clocked according the adjusted pulse pause ratio.

The on/off output with adjustable hysteresis is described on page 62.



1) Manipulated variable reading
– in operating level as Y
– in I-O/ANA menu as YPID

Fig.18 · On/off output with PPM

Note:

- *Two different configurations of the on/off output are possible:*
  (1) on/off output to monitor the limit of error signal XD or controlled variable X using limit relays L1 and L2 (see section 6.6).
  (2) on/off output to monitor the limit of the manipulated variable Y. See 'on 2.STP' setting in section 4.5.10.
- *If the on/off output is configured, the relay BO1 cannot be used for limit monitoring. If a limit monitoring (-CO- LIM2) is configured for the relay BO2, the relay no longer works as an on/off output with PPM.*
- *The minimum duty cycle is (additionally) configured in the -CO- Y.LIM function by setting the ⩡Y parameter (in percent based on the cycle duration TYL1).*
- *The maximum duty cycle is configured in the -CO- Y.LIM function by setting the ⩠Y parameter (in percent based on the cycle duration TYL1).*

OUT	**-CO- C.OUT**	On/off output or three-step output	
	PP 2.STP	On/off output with PPM	
	-PA- C.OUT/2.STP		
	KPL1	Gain Y+ (BO1)	[0.1 … **1.0** … 100.0]
	TYL1	Cycle duration Y+ (BO1)	[1.0 … **10.0** … 9999 s]
	⩡ TYL1	Min. duty cycle Y+ (BO1)	[0.1 … **1.0** s … TYL1]
	TZ	Dead band	[0.10 … **2.00** …100.0 %]

i.PP 3.STP – Three-step output with internal position feedback and PPM

The three-step output with internal position feedback and pulse pause modulation (PPM) issues the positioning pulses with pulse pause modulation.

The position of the actuator is calculated from the entered **transit time TY** (transit time of the actuator) and the internal feedback of the positioning pulses. Note that the actual position of the actuator may differ from the calculated position.

A characteristic can be adjusted to generate the positioning pulses Y+ and Y–.

- The dead band TZ is used to adjust the distance of the zero points of both characteristics. The greater TZ is defined, the longer it takes to switch between Y+ and Y–.
- The KPL1 parameter is used to adjust the gain of the characteristic for the signal Y+.
- The KPL2 parameter is used to adjust the gain of the characteristic for the signal Y–.
- The TYL1 parameter is used to adjust the cycle duration for the signal Y+.
- The TYL2 parameter is used to adjust the cycle duration for the signal Y–.
- The ⧗TYL1 parameter is used to adjust the minimum duty cycle for the signal Y+.
- The ⧗TYL2 parameter is used to adjust the minimum duty cycle for the signal Y–.

Due to the hardware, the minimum duty cycle is at least 0.3 seconds.

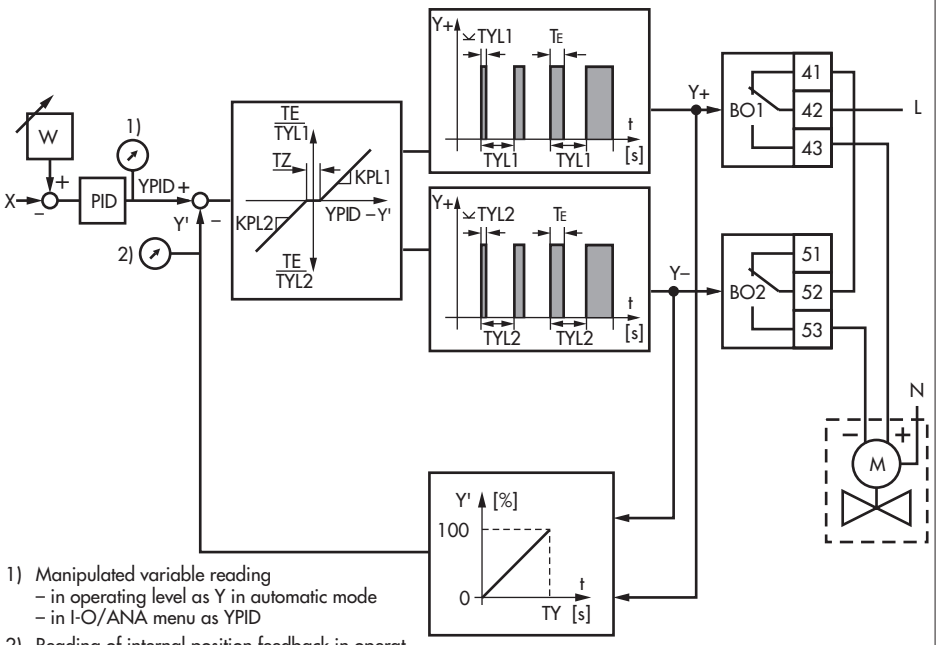
The three-step output can be adapted to various transit times, e.g. to extend or retract the actuator stem, by the gain factors and the cycle durations.

A comparator calculates the difference from the manipulated variable YPID (target position) and the feedback signal Y' (calculated actual position). Depending on the difference YPID – Y', the position pulses are generated as follows:

- The greater the positive difference is, the longer the positioning pulses Y+ will be.
- The greater the negative difference is, the longer the positioning pulses Y– will be.
- If the difference is within the range of ±TZ/2, no positioning pulse is issued.
- If the positive difference is smaller than TZ/2 + ⧗TYL1, a positioning pulse Y+ is not issued.
- If the negative difference is smaller than TZ/2 + ⧗TYL2, a positioning pulse Y– is not issued.
- If the manipulated variable YPID is smaller or equal to 0 %, the pulse Y– causes the relay BO2 to be activated constantly.
- If the manipulated variable YPID is smaller or equal to 100 %, the pulse Y+ causes the relay BO1 to be activated constantly.

In manual mode, the relays are not controlled over the three-step output.

The relay BO1 (Y+) can be actuated by pressing the △ key and the relay BO2 (Y–) by the ▽ key in manual mode.



1) Manipulated variable reading
– in operating level as Y in automatic mode
– in I-O/ANA menu as YPID

2) Reading of internal position feedback in operating level as Y in manual mode

Fig. 19 · Three-step output with internal position feedback and PPM

OUT	**-CO- C.OUT**	On/off output or three-step output	
	i.PP 3.STP	Three-step output with internal feedback and PPM	
	-PA- C.OUT/3.STP		
	KPL1	Gain Y+ (BO1)	[0.1 … **1.0** … 100.0]
	KPL2	Gain Y– (BO2)	[0.1 … **1.0** … 100.0]
	TYL1	Cycle duration Y+ (BO1)	[1.0 … **10.0** … 9999 s]
	TYL2	Cycle duration Y– (BO2)	[1.0 … **10.0** … 9999 s]
	⩓ TYL1	Min. duty cycle Y+ (BO1)	[0.1 … **1.0** s … TYL1]
	⩓ TYL2	Min. duty cycle Y– (BO1)	[0.1 … **1.0** s … TYL2]
	TZ	Dead band	[0.10 … **2.00** …100.0 %]
	TY	Transit time	[1 … **60** … 9999 s]

– **E.PP 3.STP – Three-step output with external position feedback and PPM**
The three-step output with external position feedback and pulse pause modulation (PPM) issues the positioning pulses with pulse pause modulation.
The position of the actuator is fed back, for example, by a potentiometer over the input variable WE.
A characteristic can be adjusted to generate the positioning pulses Y+ and Y–.

- The dead band TZ is used to adjust the distance of the zero points of both characteristics. The greater TZ is defined, the longer it takes to switch between Y+ and Y–.
- The KPL1 parameter is used to adjust the gain of the characteristic for the signal Y+.
- The KPL2 parameter is used to adjust the gain of the characteristic for the signal Y–.
- The TYL1 parameter is used to adjust the cycle duration for the signal Y+.
- The TYL2 parameter is used to adjust the cycle duration for the signal Y–.
- The ⧗TYL1 parameter is used to adjust the minimum duty cycle for the signal Y+.
- The ⧗TYL2 parameter is used to adjust the minimum duty cycle for the signal Y–.

Due to the hardware, the minimum duty cycle is at least 0.3 seconds.
A comparator calculates the difference from the manipulated variable YPID (target position) and the input variable WE (actual position). Depending on the difference YPID – WE, the position pulses are generated as follows:

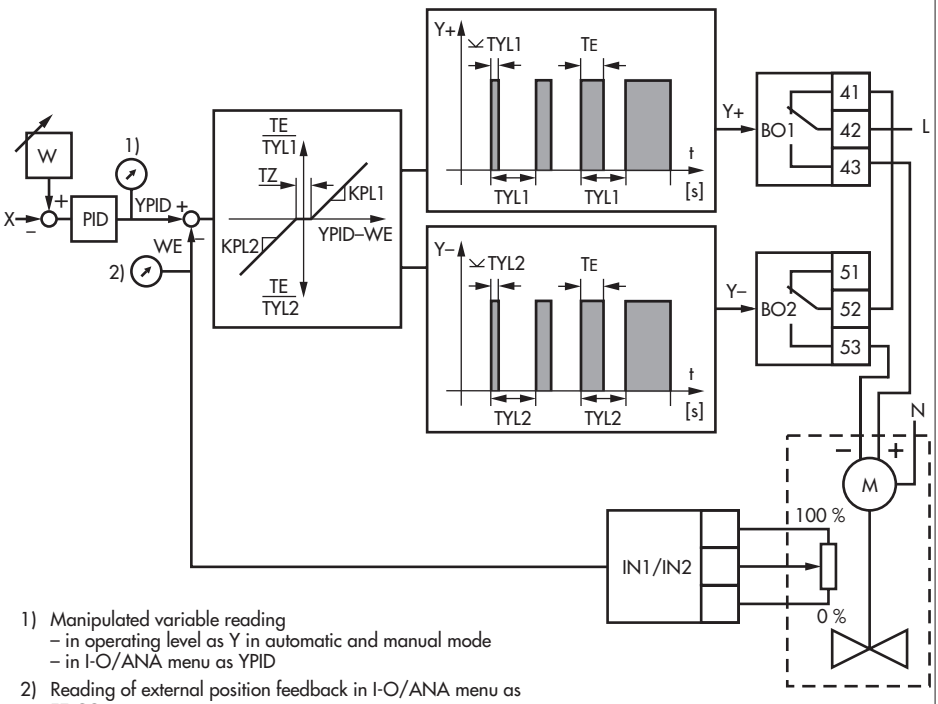
- The greater the positive difference is, the longer the positioning pulses Y+ will be.
- The greater the negative difference is, the longer the positioning pulses Y– will be.
- If the difference is within the range of ±TZ/2, no positioning pulse is issued.
- If the positive difference is smaller than TZ/2 + ⧗TYL1, a positioning pulse Y+ is not issued.
- If the negative difference is smaller than TZ/2 + ⧗TYL2, a positioning pulse Y– is not issued.

The input variable WE must be configured for position feedback.

Example: position feedback with a potentiometer at input IN2
- Configure input signal for analog input IN2:
  IN menu, -CO- IN2 function, setting 0 – 1 kOHM (-> section 6.2.2).
- Assign the input variable WE to the analog input IN2:
  IN menu, -CO- CLAS function, setting In2 WE (-> section 6.2.5).
- Assign the input variable WE to the external position feedback:
  SETP menu, -CO- SP.VA function, setting F01 WE (-> section 6.3.1).

In manual mode, the relays are controlled over the three-step output.
The manual output value Y is used to issue the target position for the three-step output.

Note: *The target position of the actuator can be limited by the -CO- Y.LIM function using the ⊻Y and ⊼Y parameters (travel limitation).*



1) Manipulated variable reading
   – in operating level as Y in automatic and manual mode
   – in I-O/ANA menu as YPID
2) Reading of external position feedback in I-O/ANA menu as FE.CO

Fig. 20 · Three-step output with external position feedback and PPM

OUT	**-CO- C.OUT**	On/off output or three-step output	
	E.PP 3.STP	Three-step output with external feedback and PPM	
	-PA- C.OUT/3.STP		
	KPL1	Gain Y+ (BO1)	[0.1 … **1.0** … 100.0]
	KPL2	Gain Y– (BO2)	[0.1 … **1.0** … 100.0]
	TYL1	Cycle duration Y+ (BO1)	[1.0 … **10.0** … 9999 s]
	TYL2	Cycle duration Y– (BO2)	[1.0 … **10.0** … 9999 s]
	⩒ TYL1	Min. duty cycle Y+ (BO1)	[0.1 … **1.0** s … TYL1]
	⩒ TYL2	Min. duty cycle Y– (BO1)	[0.1 … **1.0** s … TYL2]
	TZ	Dead band	[0.10 … **2.00** …100.0 %]

6.5.11 -CO- B.OUT: Binary outputs BO1 and BO2 for status messages

This function allows you to configure the binary outputs BO1 and BO2 to report operating states. The status of the binary outputs can be read from the I–O menu under BIN (see section 6.9.4).

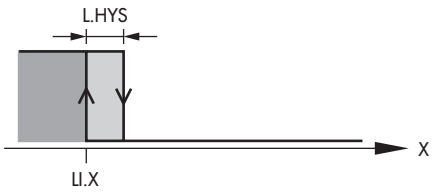
Note: *Both binary outputs cannot be used when a three-step output is configured (→ section 6.5.10). When an on/off output is configured, the BO2 can be selected in this function. All settings of B.OUT have priority over the settings for the LIM1 and LIM2 functions (see sections 6.6.1 and 6.6.2).*

OUT	**-CO- B.OUT**	Binary output BO1	
	oFF B.BO1	Off	
	F01 B.BO1	Active when binary input is set	
	F02 B.BO1	Active when WE is active	
	F03 B.BO1	Active in automatic mode	
		Binary output BO2	
	oFF B.BO2	Off	
	F01 B.BO2	Active when binary input is set	
	F02 B.BO2	Active when WE is active	
	F03 B.BO2	Active in automatic mode	

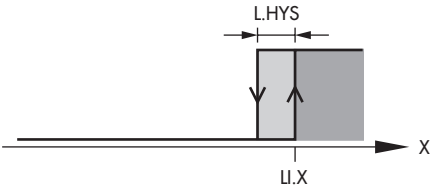
6.6 ALRM menu: Limit relays

The function of the L1 and L2 limit relays is determined in this menu.
The limit relays monitor a variable for limit violation. In the -CO- LIM1 and -CO- LIM2 functions the variable to be monitored and the condition for switching the limit relay (violation of upper or lower limit) is determined.
The limit is defined in the parameter level in the LI.X, LI.WE, LI.YPID or LI.XD parameter. Additionally, an on/off differential (hysteresis) must be determined in the L.HYS parameter. This hysteresis is the distance between the relay switches on and off. It is specified in percent based on the measuring range.
Figs. 21 and 22 show how the limit relays function based on an example in which the controlled variable X is monitored with a list of the parameter settings. The diagrams show that when a variable is monitored for violation of the upper limit, the limit relay is activated when the adjusted limit LI.X, LI.WE, LI.YPID or LI.XD is exceeded. In the other direction, the limit relay is deactivated when the variable falls below the limit minus the hysteresis L.HYS. If a variable is monitored for violation of the lower limit by the limit relay, the limit relay is activated when the variable falls below LI.X, LI.WE, LI.YPID or LI.XD. In the other direction, the limit relay is deactivated when the limit is exceeded minus the hysteresis L.HY

An active limit relay is indicated on the display by the L1 icon for limit relay 1 or L2 for limit relay 2.

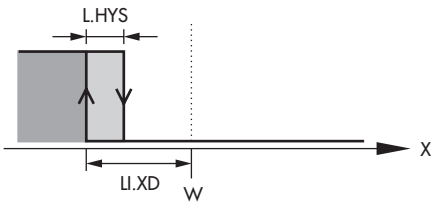


Controlled variable X lower than the limit
-CO- LIM1: Lo L1.X
-PA- LI.X = 10.0 °C
-PA- L.HYS = 0.5 %

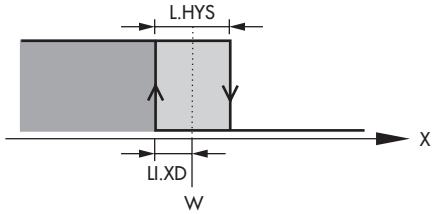


Controlled variable X higher than the limit
-CO- LIM1: Hi L1.X
-PA- LI.X = 90.0 °C
-PA- L.HYS = 0.5 %

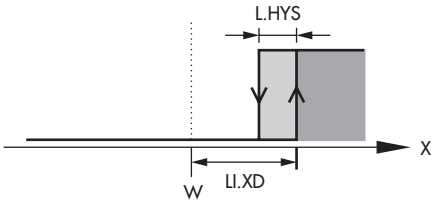
Fig. 21 · Functioning of limit relays L1 and L2: example illustrating how L1 functions – Part 1



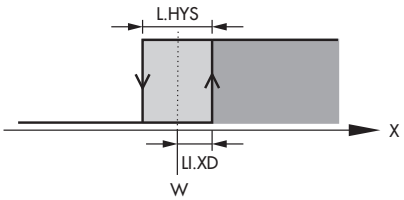
Error signal XD higher than the limit
-CO- LIM1: Hi L1.XD
-PA- LI.XD = 1.5 %
-PA- L.HYS = 0.5 %



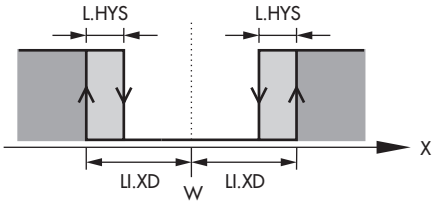
Error signal XD higher than the limit
Application: On/off controller for heating
-CO- LIM1: Hi L1.XD
-PA- LI.XD = 0.5 %
-PA- L.HYS = 1.0 %



Error signal XD lower than the limit
-CO- LIM1: Lo L1.XD
-PA- LI.XD = –1.5 %
-PA- L.HYS = 0.5 %



Error signal XD lower than the limit
Application: On/off controller for cooling
-CO- LIM1: Lo L1.XD
-PA- LI.XD = –0.5 %
-PA- L.HYS = 1.0 %



Absolute value of XD higher than the limit
-CO- LIM1: AbS L1.XD
-PA- LI.XD = 1.5 %
-PA- L.HYS = 0.5 %

Fig. 22 · Functioning of limit relays L1 and L2: example illustrating how L1 functions – Part 2

6.6.1 -CO- LIM1: Limit relay L1

You can determine the variable to be monitored and the condition for switching the limit relay L1 (violation of the upper or lower limit) with this function. Section 6.6 contains a detailed description on how the limit relay works.

Note: *The functions of the on/off or three-step output -CO- C.OUT (→ section 6.5.10) and the functions for the binary outputs -CO- B.OUT (→ section 6.5.11) have priority over the settings of the -CO- LIM1 and -CO- LIM2 functions.*

ALRM	**-CO- LIM1**	Limit relay L1	
	oFF L1	Off	
	Lo L1.X	When X is not reached	
	Hi L1.X	When X is exceeded	
	Lo L1.WE	When WE is not reached	
	Hi L1.WE	When WE is exceeded	
	Lo L1.YP	When YPID is not reached	
	Hi L1.YP	When YPID is exceeded	
	Lo L1.XD	When XD is not reached	
	Hi L1.XD	When XD is exceeded	
	AbS L1.XD	When absolute value of XD is exceeded	
	-PA- LIM1/L1		
	LI.X	Limit for X	[⩡ IN1 … **100.0** … ⩠ IN1] [⩡ IN2 … **100.0** … ⩠ IN2]
	LI.WE	Limit for WE	[⩡ IN1 … **100.0** … ⩠ IN1] [⩡ IN2 … **100.0** … ⩠ IN2]
	LI.YP	Limit for YPID	[⩡ Y … **100.0 %** … ⩠ Y]
	LI.XD	Limit for XD	[–110.0 … **0.0** … 110.0 %]
	LI.HYS	Hysteresis	[0.10 … **0.50** … 100.0 %]

6.6.2 -CO- LIM2: Limit relay L2

You can determine the variable to be monitored and the condition for switching the limit relay L2 (violation of the upper or lower limit) with this function. Section 6.6 contains a detailed description on how the limit relay works.

Note: *The functions of the on/off or three-step output -CO- C.OUT (→ section 6.5.10) and the functions for the binary outputs -CO- B.OUT (→ section 6.5.11) have priority over the settings of the -CO- LIM1 and -CO- LIM2 functions.*

ALRM	**-CO- LIM2**	Limit relay L2	
	oFF L2	Off	
	Lo L2.X	When X is not reached	
	Hi L2.X	When X is exceeded	
	Lo L2.WE	When WE is not reached	
	Hi L2.WE	When WE is exceeded	
	Lo L2.YP	When YPID is not reached	
	Hi L2.YP	When YPID is exceeded	
	Lo L2.XD	When XD is not reached	
	Hi L2.XD	When XD is exceeded	
	AbS L2.XD	When absolute value of XD is exceeded	
	-PA- LIM2/L2		
	LI.X	Limit for X	[⩡ IN1 … **100.0** … ⩠ IN1] [⩡ IN2 … **100.0** … ⩠ IN2]
	LI.WE	Limit for WE	[⩡ IN1 … **100.0** … ⩠ IN1] [⩡ IN2 … **100.0** … ⩠ IN2]
	LI.YP	Limit for YPID	[⩡ Y … **100.0 %** … ⩠ Y]
	LI.XD	Limit for XD	[–110.0 … **0.0** … 110.0 %]
	LI.HYS	Hysteresis	[0.10 … **0.50** … 100.0 %]

6.7 AUX menu: Additional functions

6.7.1 -CO- RE.CO: Restart conditions after power failure

This function allows you to determine which operating mode and which output value is to be used by the controller after a restart due to a power supply failure.

- **F01 MODE:** Manual mode with constant output value Y1K1
- **F02 MODE:** Automatic mode, start with output value Y1K1 and the currently valid set point

AUX	**-CO- RE.CO**	Restart conditions after power failure	
	F01 MODE	Manual mode with constant output value Y1K1	
	F02 MODE	Auto, start with output value Y1K1	
	-PA- RE.CO/MODE		
	Y1K1	Constant output value	[–10.0 … **0.0** … 110.0 %]

6.7.2 -CO- ST.IN: Reset to default settings

This function allows you to reset all parameters, functions and calibrated values to their default settings. After a reset, the message "FrEE INIT" is generated.

AUX	**-CO- ST.IN**	Reset to default settings
	FrEE INIT	Off
	AII INIT	All functions, parameters + key code
	FUnC INIT	All functions
	PArA INIT	All parameters + key code
	AdJ INIT	Calibration values for IN1, IN2, Y

6.7.3 -CO- KEYL: Lock control keys

The keys can be locked:

- **bi1 LOCK:** All keys locked by binary input BI
- **on noH.W:** Keys , , and are locked. The controller remains in the operating mode active before the keys were locked.

AUX	**-CO- KEYL**	Lock control keys
	oFF LOCK	Off
	bi1 LOCK	Switched on/off by binary input BI1
	on noH.W	Selector, manual/automatic and cursor keys off

Note: *Several functions can be assigned to the binary input.* *See page 32.*

6.7.4 -CO- VIEW: Top/bottom viewing angle of display

The contrast for the top and bottom viewing angle of the display can be changed from Level 1 to Level 10.
The default setting (Level 6) only needs to be changed in extreme installation situations.

AUX	**-CO- VIEW**	Top/bottom viewing angle of display
	01 VIEW	Level 1
	…	…
	06 VIEW	Level 6
	…	…
	10 VIEW	Level 10

6.7.5 -CO- FREQ: Power line frequency (ripple filter)

This function is used to filter out 50 Hz or 60 Hz ripple signals from the input signal at the analog input. Select the power frequency (50 Hz or 60 Hz) of the low-voltage installation. The power frequency must be set even when the controller is operated by DC voltage.

AUX	**-CO- FREQ**	Power line frequency
	on 50Hz	50 Hz
	on 60Hz	60 Hz

6.7.6 -CO- DP: Decimal separator setting

This function is used to select the number of digits after the decimal point for the controlled variable and set point reading.
In addition, you can select the number of digits after the decimal point for parameters directly related to the analog inputs. These parameters include:

- Measuring ranges of the analog inputs
- Function generation of the input variables X and WE
- Limit values LI.X and LI.WE for the limit monitoring of the input variables X and WE

If the measured value (parameter value) is too large, meaning the decimal point cannot be displayed in the reading, the number of digits after the decimal point is automatically reduced. After the measured value (parameter value) becomes smaller again, its reading automatically returns to the configured number of digits after the decimal point.

AUX	**-CO- DP**	Decimal separator setting
	on DP1	No digit
	on DP2	One digit
	on DP3	Two digits

6.8 -CO- TUNE: Start-up adaptation

The purpose of the adaptation is to quickly determine the best settings for the control parameters KP, TN and TV with minimum knowledge of the process to be controlled.

The KP, TN and TV parameters are calculated according to the rules introduced by Chien, Hrones and Reswick for the aperiodic control operation and a good timing behavior.

The following points must be observed:

- The adaptation can only be used for controlled systems with self-regulation.
- The controlled variable must be as constant as possible at the beginning of the adaptation.
- The disturbance variables must not be changed during the adaptation.

First set the manipulated variable Y to a start value. The start-up adaption is started when you select 'run ADP.S'. The analog output is stepped up or down by the step change value of the manipulated variable (Y.JMP parameter). The controller waits for the response from the controlled system until a new stable state of the controlled variable is reached. The controller then determines the control parameters from the course of the controlled variable. After the adaptation is completed, the controller issues the output value again which was active in manual mode before the adaptation.

Before the adaptation, the operating point of the manipulated variable must be known. You can find it in the manual mode by adjusting the manipulated variable Y in manual mode so that the controlled variable X has the same value as the set point W.

The step change of the manipulated variable must be large as possible and be located around the operating point (e.g. start value above the operating point and end value below it). On determining the step change value Y.JMP and the start value, make sure that the manipulated variable is within the range of the manipulated variable and that the controlled variable is within the measuring range. Furthermore, make sure the controlled variable for the process does not assume any impermissible values. Check this point before the adaptation. To do this, set the manipulated variable in manual mode after the step change and then before the step change.

To run start-up adaption, proceed as follows:

The compact controller is in the operating level.

1. In manual mode, set the manipulated variable Y to the operating point so that the controlled variable X has the same value as the set point W.
2. Increase the manipulated variable Y, for example by 10 % (with step change value of the manipulated variable Y.JMP = 20 %) and wait until the controlled variable X does not change anymore.
3. Check whether the controlled variable is within the permissible range.
4. Reduce the manipulated variable Y, for example by 20 % (with step change value of the manipulated variable Y.JMP = 20 %) and wait until the controlled variable X does not change anymore
5. Check whether the controlled variable is within the permissible range.
6. In TUNE menu, select -CO- ADAP function and set the step change value Y.JMP.
7. In TUNE menu, select -CO- ADAP function. Select 'run ADP.S' to start the adaptation. How long the adaptation takes is determined by the time behavior of the controlled system.
   If the controlled variable does not reach an end value within five hours, the adaptation is automatically cancelled.

After starting the adaptation, status messages on the start-up adaptation are displayed in the top row.

Status messages

- 10 Adaptation started
- 20 Noise measurement (approx. 10 seconds)
- 40 Step value of manipulated variable ($Y = Y_{PID} + Y.JMP$) issued
  Wait for controlled system to react (step response)
- 41 Step value of manipulated variable ($Y = Y_{PID} + Y.JMP$) issued
  Wait for controlled system to settle
- 50 Returned to output value before starting adaptation
  Determining parameter
- 70, 71, 72, End Adaptation finished

Note: *You can cancel the adaptation by pressing the* *key.*

If an error occurs during adaptation, the error appears on the display and the binary output for fault alarms is activated.

Error messages

- 30 ERR Adaptation is completed after five hours at the maximum
- 31 ERR No parameters could be determined
- 32 ERR The signal at the X input is smaller than 0 % or greater than 100 %.
  Recommended action: Change Y.JMP.
- 33 ERR Too much noise
  Recommended action: Increase Y.JMP.
- 34 ERR Selected PID setting does not allow start-up adaptation.
  Recommended action: In -CO- C.PID function, select control algorithm P, PI or PID.
- 35 ERR Control signal Y is smaller than 0 % or greater than 100 %.
  Recommended action: Change Y.JMP.
- 36 ERR Malfunction
  Recommended action: Restart adaptation.

TUNE	**-CO- ADAP**	Start-up adaptation	
	oFF ADP.S	Off	
	run ADP.S	Start	
	-PA- ADAP		
	KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]
	TN	Reset time	[1 … **120** … 9999 s]
	TV	Derivative-action time	[1 … **10** … 9999 s]
	Y.JMP	Step change value of manipulated variable	[–100.0 … **20.0** … 100.0 %]

6.9 I-O menu: Process data

This menu enables you to view different variables and data. In addition, you can calibrate zero and span for the analog inputs IN1 and IN2 as well as the analog output Y.

6.9.1 -CO- CIN: Firmware version

Firmware version reading

I-O	**-CO- CIN**	Firmware version

6.9.2 -CO- S-No: Serial number

Serial number reading

I-O	**-CO- S-No**	Serial number

6.9.3 -CO- ANA: Read analog inputs and outputs

The analog values are shown in this function.

I-O	**-CO- ANA**	Analog values
	IN1	Analog input IN1
	IN2	Analog input IN2
	CO.VA	Controlled variable before function generation
	WE.VA	WE before function generation
	FE.CO	WE after function generation
	SP.CO	Set point at comparator
	YPID	YPID after limitation
	YOUT	Analog output

6.9.4 -CO- BIN: Read binary inputs and outputs

You can read the states of the binary input and those of the binary outputs in this function.

I-O	**-CO- BIN**	Binary values
	BI1	Binary input BI
	BO1	Binary output BO1
	BO2	Binary output BO2

6.9.5 -CO- ADJ: Calibration of analog inputs and analog output

This function allows you to perform a calibration of the zero and span for the analog inputs and the analog output.
The analog inputs and the analog output are calibrated by default (factory calibration).

By performing a user calibration based on the system, long cables, small cable cross-sections or tolerances of the sensors and final control elements can be compensated for. The user calibration can be reset to the factory calibration (AUX menu, -CO- ST.IN function, AdJ INIT setting. Refer to section 6.7.2).

I-O	-CO- ADJ	Calibration
	AdJ IN1	Analog input IN1
	AdJ IN2	Analog input IN2
	AdJ YOUT	Analog output

Calibrating the analog input:

1. Connect a high-precision meter at the input (IN1, IN2).
2. In I-O menu, select the function ADJ.
3. Select the input you want to calibrate (AdJ IN1, AdJ IN2) using the cursor keys (△, ▽).
4. Confirm the input you have selected (□).
   You are prompted to enter the key number.
5. Enter the key number or continue by pressing □.
6. Use the high-precision meter to set the input signal to the required start value.
   Display: ZERO and IN1 (IN2) in alternating sequence
7. Confirm the start value (□).
   Display: 0.0 and ZERO
8. Use the high-precision meter to set the input signal to the required end value.
   Display: SPAN and IN1 (IN2) in alternating sequence
9. Confirm the end value (□).
   Display: 100.0 and SPAN

Calibrating the analog output:

1. Connect a high-precision meter at the analog output (Y).
2. In I-O menu, select ADJ.
3. Select the output (AdJ YOUT) using the cursor keys (△, ▽).
4. Confirm the output (□).
   You are prompted to enter the key number.
5. Enter the key number or continue by pressing □.
6. Use the cursor keys (△, ▽) to set the start value at the high-precision meter.
   Display: ZERO and YOUT in alternating sequence

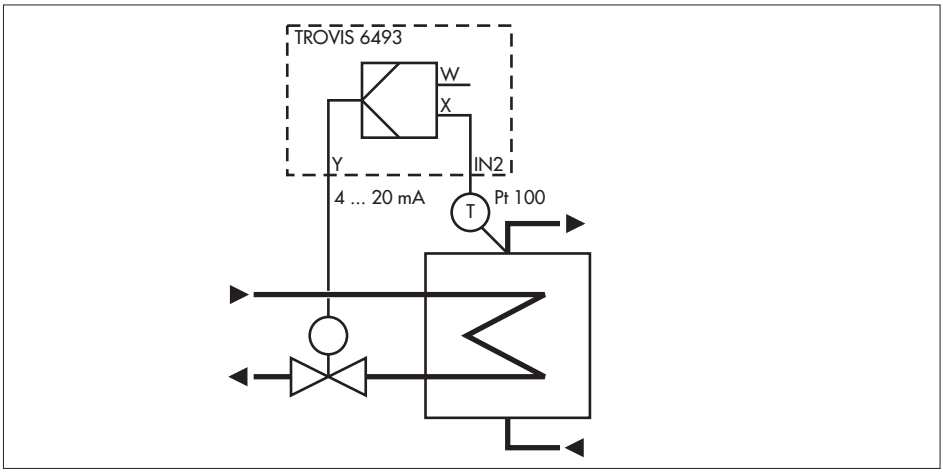
7. Confirm the start value ( ).
   Display: 0.0 and ZERO
8. Use the cursor keys (,) to set the end value at the high-precision meter.
   Display: SPAN and YOUT in alternating sequence
9. Confirm the end value ( ).
   Display: 100.0 and SPAN

7 Typical applications

7.1 Temperature control

Example 1:
Flow temperature control of a heat exchanger
(fixed set point control with Pt 100 input and mA output)

The controller receives the flow temperature T in the secondary circuit at input IN1 from a resistance thermometer Pt 100 and positions the control valve in the primary circuit by issuing a 4-20 mA signal at the output Y to keep the flow temperature constant at 50 °C.



Based on the default settings, only the settings marked by ⇒ need to be made.

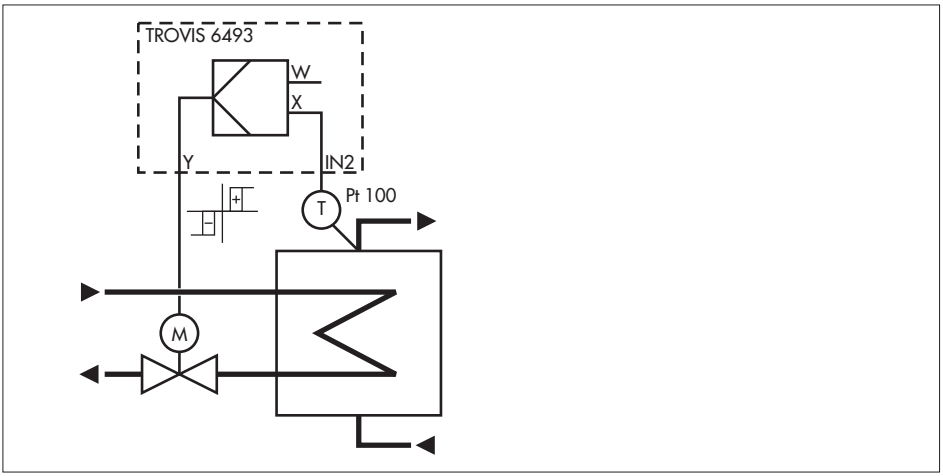
		PAR		
Proportional-action coefficient (depending on system)	⇒	-PA-	KP	= 1.0
Reset time (depending on system)	⇒		TN	= 120 s
		IN		
Input IN2: Input signal Pt 100		-CO-	IN2	= 100 PT
Input IN2: Lower measuring range value 0 °C		-PA-	⩡IN2	= 0.0 °C
Input IN2: Upper measuring range value 100 °C			⩠IN2	= 100.0 °C
Input variable X: Input IN2		-CO-	CLAS	= In2 X

		SETP	
		-CO-	SP.VA = on W
Internal set point: 50 °C	⇒	-PA-	W = 50.0 °C
		CNTR	
Control behavior: PI		-CO-	C.PID = PI CP.YP
Operating direction: Increasing		-CO-	DIRE = dir.d DI.AC
		OUT	
Output signal Y: 4 – 20 mA		-CO-	Y.VA = 4–20 mA
		AUX	
Restart conditions after power failure: Automatic mode		-CO-	RE.CO = F02 MODE
Initial value of manipulated variable Y			Y1K1 = 0.0 %

Example 2:
Flow temperature control of a heat exchanger
(fixed set point control with Pt 100 input and three-step output)

The controller receives the flow temperature T in the secondary circuit at input IN2 from a resistance thermometer Pt 100 and positions the control valve in the primary circuit over the three-step output to keep the flow temperature constant at 50 °C.

The transit time of the electric actuator is 120 s.



Based on the default settings, only the settings marked by ⇒ need to be made.

		PAR		
Proportional-action coefficient (depending on system)	⇒	-PA-	KP	= 1.0
Reset time (depending on system)	⇒		TN	= 120 s
		IN		
Input IN2: Input signal Pt 100		-CO-	IN2	= 100 PT
Input IN2: Lower measuring range value 0 °C		-PA-	⩡IN2	= 0.0 °C
Input IN2: Upper measuring range value 100 °C			⩠IN2	= 100.0 °C
Input variable X: Input IN2		-CO-	CLAS	= In2 X
		SETP		
		-CO-	SP.VA	= on W
Internal set point: 50 °C	⇒	-PA-	W	= 50.0 °C
		CNTR		
Control behavior: PI		-CO-	C.PID	= PI CP.YP
Operating direction: Increasing		-CO-	DIRE	= dir.d DI.AC
		OUT		
Three-step output with internal feedback	⇒	-CO-	C.OUT	= i.Fb 3.STP
Hysteresis		-PA-	XSDY	= 0.5 %
Dead band			TZ	= 2.0 %
Transit time (actuator)	⇒		TY	= 120 s
		AUX		
Restart conditions after power failure: Automatic mode		-CO-	RE.CO	= F02 MODE
Initial value of manipulated variable Y			Y1K1	= 0.0 %

Variation on example 2:

If the measured temperature is to be issued at the analog output as a 4–20 mA signal, perform the following settings:

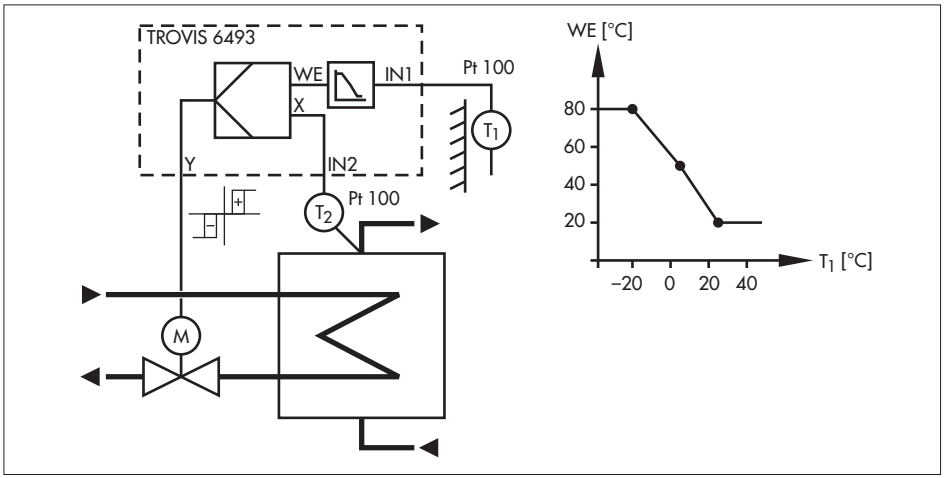
		OUT		
Output signal Y: 4 – 20 mA		-CO-	Y.VA	= 4–20 mA
Assign output to input variable X	⇒		Y.SRC	= on Y.X

Example 3:
Outdoor-temperature-based control of the flow temperature of a heat exchanger (follow-up control with Pt 100 input and three-step output)

The controller receives the flow temperature T2 in the secondary circuit at input AI2 from a resistance thermometer Pt 100 and positions the control valve in the primary circuit over the three-step output to keep the flow temperature constant.

In the outdoor-temperature-based control, the set point is determined by the outdoor temperature. For this purpose, the outdoor temperature T1 is measured by a resistance thermometer Pt 100 at input AI1. This input is assigned to the input variable WE. The set point for the flow temperature is calculated from the outdoor temperature by performing a function generation of the input variable WE.

	1	2	3	4	5	6	7
Outdoor temperature T1 in °C	–20.0	5.0	25.0	25.0	25.0	25.0	25.0
Set point for T2 in °C	80.0	50.0	20.0	20.0	20.0	20.0	20.0



Based on the default settings, only the settings marked by ⇒ need to be made.

		PAR		
Proportional-action coefficient (depending on system)	⇒	-PA-	KP	= 1.0
Reset time (depending on system)	⇒		TN	= 120 s

		IN		
Input IN1: Input signal Pt 100	⇒	-CO-	IN1	= 100 PT
Input IN1: Lower measuring range value 0 °C		-PA-	⊻IN1	= 0.0 °C
Input IN1: Upper measuring range value 100 °C			⊼IN1	= 100.0 °C
Input IN2: Input signal Pt 100		-CO-	IN2	= 100 PT
Input IN2: Lower measuring range value 0 °C		-PA-	⊻IN2	= 0.0 °C
Input IN2: Upper measuring range value 100 °C			⊼IN2	= 100.0 °C
Input variable X: Input IN2		-CO-	CLAS	= In2 X
Input variable WE: Input IN1				= In1 WE
Function generation of input variable WE	⇒	-CO-	FUNC	= on WE
Lower range value of output signal		-PA-	MIN	= 0.0 °C
Upper range value of output signal		-PA-	MAX	= 100.0 °C
Input value 1	⇒	-PA-	K1.X	= –20.0 °C
Output value 1	⇒	-PA-	K1.Y	= 80.0 °C
Input value 2	⇒	-PA-	K2.X	= 5.0 °C
Output value 2	⇒	-PA-	K2.Y	= 50.0 °C
Input value 3	⇒	-PA-	K3.X	= 25.0 °C
Output value 3	⇒	-PA-	K3.Y	= 20.0 °C
Input value 4	⇒	-PA-	K4.X	= 25.0 °C
Output value 4	⇒	-PA-	K4.Y	= 20.0 °C
Input value 5	⇒	-PA-	K5.X	= 25.0 °C
Output value 5	⇒	-PA-	K5.Y	= 20.0 °C
Input value 6	⇒	-PA-	K6.X	= 25.0 °C
Output value 6	⇒	-PA-	K6.Y	= 20.0 °C
Input value 7	⇒	-PA-	K7.X	= 25.0 °C
Output value 7	⇒	-PA-	K7.Y	= 20.0 °C
		SETP		
		-CO-	SP.VA	= on W
Internal set point: 25 °C	⇒	-PA-	W	= 25.0 °C
Enable external set point WE	⇒	-CO-	SP.VA	= on WE
		CNTR		
Control behavior: PI		-CO-	C.PID	= PI CP.YP
Operating direction: Increasing		-CO-	DIRE	= dir.d DI.AC

		OUT		
Three-step output with internal feedback	⇒	-CO-	C.OUT	= i.Fb 3.STP
Hysteresis		-PA-	XSDY	= 0.5 %
Dead band			TZ	= 2.0 %
Transit time (actuator)	⇒		TY	= 120 s
		AUX		
Restart conditions after power failure: Automatic mode		-CO-	RE.CO	= F02 MODE
Initial value of manipulated variable Y			Y1K1	= 0.0 %

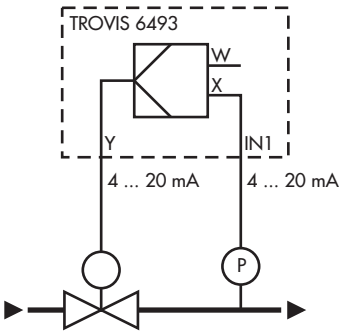
Activate the external set point WE in the operating level:

1. Press ▭ until WE appears on the display (WE blinks).
2. Press ▭ to activate WE (WE stops blinking).

7.2 Pressure control

Example 4:
Pressure control
(fixed set point control with mA input and mA output)

The controller receives the pressure downstream of the control valve as a 4 to 20 mA signal from a transmitter at input IN1 and issues a 4 to 20 mA signal at output Y to position the valve to keep the pressure constant at 6 bar. The measuring range of the transmitter is 0 to 10 bar.

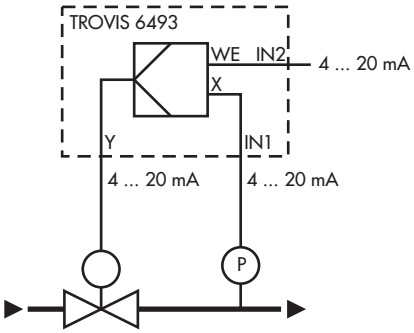


Based on the default settings, only the settings marked by ⇒ need to be made.

		PAR		
Proportional-action coefficient (depending on system)	⇒	-PA-	KP	= 1.0
Reset time (depending on system)	⇒		TN	= 10 s
		IN		
Input IN1: Input signal 4 to 20 mA		-CO-	IN1	= 4–20 mA
Input IN1: Lower measuring range value 0 bar		-PA-	⊻IN1	= 0 bar
Input IN1: Upper measuring range value 10 bar	⇒		⊼IN1	= 10 bar
Input variable X: Input IN1	⇒	-CO-	CLAS	= In1 X
		SETP		
		-CO-	SP.VA	= on W
Internal set point: 6 bar	⇒	-PA-	W	= 6 bar
		CNTR		
Control behavior: PI		-CO-	C.PID	= PI CP.YP
Operating direction: Increasing		-CO-	DIRE	= dir.d DI.AC
		OUT		
Output signal: 4 to 20 mA		-CO-	Y.VA	= 4–20 mA
		AUX		
Restart conditions after power failure: Automatic mode		-CO-	RE.CO	= F02 MODE
Initial value of manipulated variable Y			Y1K1	= 0.0 %

Example 5:
Pressure control
(fixed set point control with mA input and mA output)

The controller receives the pressure downstream of the control valve as a 4 to 20 mA signal from a transmitter at input IN1 and issues a 4 to 20 mA signal at output Y to position the valve to keep the pressure constant at 6 bar. A 4 to 20 mA signal is used to issue the external set point. The measuring range of the transmitter is 0 to 10 bar.



Based on the default settings, only the settings marked by ⇒ need to be made.

		PAR		
Proportional-action coefficient (depending on system)	⇒	-PA-	KP	= 1.0
Reset time (depending on system)	⇒		TN	= 10 s
		IN		
Input IN1: Input signal 4 to 20 mA		-CO-	IN1	= 4–20 mA
Input IN1: Lower measuring range value 0 bar		-PA-	⊻IN1	= 0 bar
Input IN1: Upper measuring range value 10 bar	⇒		⊼IN1	= 10 bar
Input IN2: Input signal: 4-20 mA		-CO	IN2	= 4–20 mA
Input IN2: Lower measuring range value: 0 bar			⊻IN2	= 0 bar
Input IN2: Upper measuring range value: 10 bar	⇒		⊼IN2	= 10 bar
Input variable X: Input IN1	⇒	-CO-	CLAS	= In1 X
Input variable WE: Input IN2				= In2 WE

		SETP		
		-CO-	SP.VA	= on W
Internal set point 6 bar	⇒	-PA-	W	= 6 bar
Enable external set point WE	⇒	-CO-	SP.VA	= on WE
		CNTR		
Control behavior: PI		-CO-	C.PID	= PI CP.YP
Operating direction: Increasing		-CO-	DIRE	= dir.d DI.AC
		OUT		
Output signal: 4 to 20 mA		-CO-	Y.VA	= 4–20 mA
		AUX		
Restart conditions after power failure: Automatic mode		-CO-	RE.CO	= F02 MODE
Initial value of manipulated variable Y			Y1K1	= 0.0 %

Activate the external set point WE in the operating level:

1. Press ▭ until WE appears on the display (WE blinks).
2. Press ▭ to activate WE (WE stops blinking).

8 Start-up

The controller must be installed (section 3), wired (section 4) and adapted to the control task by performing the configuration and parameterization. You can write down the settings you have made in the configuration protocol on page 124.

Optimizing the control parameters

The controller must be adapted to the dynamic behavior of the controlled system over the parameters KP, TN and TV to ensure that system deviations caused by disturbances can be eliminated or largely suppressed. There are two ways to tune these parameters, either by performing the start-up adaption (section 6.8) or by manual optimization. The latter is described in the following sections. We can only give general instructions.

Proceed as follows for a PI controller:

1. Change to manual mode ( ).
2. In CNTR menu, select the function -CO- C.PID = PI CP.YP.
3. In PAR menu, set the parameters KP = 0.1 and TN = 9999 s.
4. In the operating level, set the set point W to the required value.
   To do this, select W by pressing and adjust the value using the cursor keys (,).
5. In the operating level, change the manipulated variable Y so that the controlled variable X has the same value as the set point W (error XD = 0).
   To do this, select Y by pressing and adjust the value using the cursor keys (,).
6. Change to automatic mode ( ).
7. In PAR menu, step up the KP parameter until the controlled system shows a tendency to oscillate. Every time the KP increases, let the controlled system oscillate, e.g. by making small changes in the set point.
8. In PAR menu, reduce the KP parameter again until the controlled system stops oscillating.
9. In PAR menu, step down the TN parameter until the controlled system starts to oscillate. Every time the TN is reduced, let the controlled system to oscillate, e.g. by making small changes in the set point.
10. In PAR menu, raise the TN parameter slightly until the controlled system stops oscillating.
11. Change the set point slightly and check the transient behavior. If necessary, retune KP and TN until the closed loop has a satisfactory control behavior.

Proceed as follows for a P controller

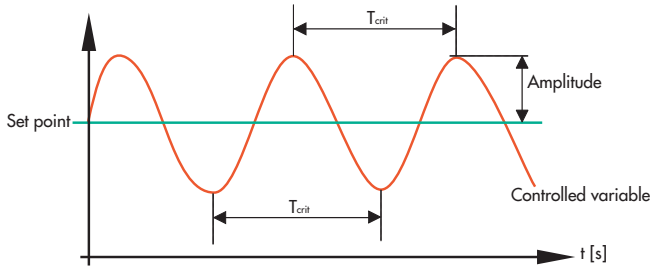
1. Change to manual mode ( ).
2. In CNTR menu, set the function -CO- C.PID = P CP.YP.
3. In PAR menu, set the parameter KP = 0.1.
4. In the operating level, set the set point W to the required value.
   To do this, select W by pressing and adjust the value using the cursor keys (,).
5. In the operating level, change the manipulated variable Y so that the controlled variable X has the same value as the set point W (error XD = 0).
   To do this, select Y by pressing and adjust the value using the cursor keys (,).
   The output Y reading is the operating point of the manipulated variable.
6. In PAR menu, set the Y.PRE parameter to the previously determined operating point of the manipulated variable Y.
   NOTE: For a P controller, every time the set point is changed, the change of the operating point is also necessary if no system deviation is to exist.
7. Change to automatic mode ( ).
8. In PAR menu, step up the KP parameter until the controlled system shows a tendency to oscillate. Every time the KP increases, let the controlled system oscillate, e.g. by making small changes in the set point.
9. In PAR menu, reduce the KP parameter again until the controlled system stops oscillating.

8.1 Tuning according to the Ziegler and Nichols method

Various tuning methods, such as the Ziegler and Nichols method, are described in control engineering literature. The Ziegler and Nichols tuning method can only be applied to controlled systems that allow the controlled variable to start to oscillate itself. For the frequency responese test, the controller must run with P action in closed-loop operation.

Proceed as follows for a PI controller

1. Change to manual mode ( ).
2. In CNTR menu, set the function -CO- C.PID = PI CP.YP.
3. In PAR menu, set the parameters KP = 0.1 and TN = 9999 s.
4. In the operating level, set the set point W to the required value.
   To do this, select W by pressing and adjust the value using the cursor keys (,).
5. In the operating level, change the manipulated variable Y so that the controlled variable X has the same value as the set point W (error XD = 0).
   To do this, select Y by pressing and adjust the value using the cursor keys (,).
6. Change to automatic mode ( ).
7. In PAR menu, step up the KP parameter until the controlled variable shows an harmonic oscillation pattern.
   Every time the KP increases, let the controlled system oscillate, e.g. by making small changes in the set point.
8. Write down the adjusted KP value as the critical proportional-action coefficient $K_{P,crit}$.
9. Use a stopwatch to time the oscillation time for one entire oscillation to find T_{crit}.
   To achieve a more precise result, time several oscillations and calculate the average time from the results.



10. Multiply $K_{P,crit}$ and T_{crit} by the factors listed in the table below. Use the results for KP and TN accordingly.

	KP	TN	TV
PI controller	$0.45 \cdot K_{P,crit}$	$0.85 \cdot T_{crit}$	–

11. Change the set point slightly and check the transient behavior. If necessary, retune KP and TN until the closed loop shows a satisfactory control behavior.

Proceed as follows for a P controller

1. Change to manual mode ( ).
2. In CNTR menu, set the function -CO- C.PID = P CP.YP.
3. In PAR menu, set the parameter KP = 0.1.
4. In the operating level, set the set point W to the required value.
   To do this, select W by pressing and adjust the value using the cursor keys (,).
5. In the operating level, change the manipulated variable Y so that the controlled variable X has the same value as the set point W (error XD = 0).
   To do this, select Y by pressing and adjust the value using the cursor keys (,).
   The output Y reading is the operating point of the manipulated variable.
6. In PAR menu, set the Y.PRE parameter to the previously determined operating point of the manipulated variable Y.
   NOTE: For a P controller, every time the set point is changed, the change of the operating point is also necessary if no system deviation is to exist.
7. Change to automatic mode ( ).
8. In PAR menu, step up the KP parameter until the controlled variable shows an harmonic oscillation pattern.
   Every time the KP increases, let the controlled system oscillate, e.g. by making small changes in the set point.
9. Write down the adjusted KP value as the critical proportional-action coefficient $K_{P,crit}$.
10. Multiply $K_{P,crit}$ by the factor 0.5 and use the result to set KP at the controller ($KP = 0.5 \cdot K_{P,crit}$).

	KP	TN	TV
P controller	$0.5 \cdot K_{P,krit}$	–	–

11. Change the set point slightly and check the transient behavior. If necessary, retune KP slightly until the closed loop shows a satisfactory control behavior.

Proceed as follows for a PID controller

1. Change to manual mode ( ).
2. In CNTR menu, set the function -CO- C.PID = PI CP.YP.
3. In PAR menu, set the parameter KP = 0.1 and TN = 9999 s.
4. In the operating level, set the set point W to the required value.
   To do this, select W by pressing and adjust the value using the cursor keys (,).
5. In the operating level, change the manipulated variable Y so that the controlled variable X has the same value as the set point W (error XD = 0).
   To do this, select Y by pressing and adjust the value using the cursor keys (,).
6. Change to automatic mode ( ).
7. In PAR menu, step up the KP parameter until the controlled variable shows an harmonic oscillation pattern.
   Every time the KP increases, let the controlled system oscillate, e.g. by making small changes in the set point.
8. Write down the adjusted KP value as the critical proportional-action coefficient $K_{P,crit}$.
9. Use a stopwatch to time the oscillation time for one entire oscillation to find Tcrit.
   To achieve a more precise result, time several oscillations and calculate the average time from the results.
10. In CNTR menu, set the function -CO- C.PID = PID CP.YP and change again to automatic mode.
11. Multiply $K_{P,crit}$ and T_{crit} by the factors listed in the table below. Use these results for KP, TN and TV accordingly.

	KP	TN	TV
PID controller	$0.59 \cdot K_{P,crit}$	$0.50 \cdot T_{crit}$	$0.12 \cdot T_{crit}$

11. Change the set point slightly and check the transient behavior. If necessary, retune KP, TN and TV slightly until the closed loop shows a satisfactory control behavior.

9 Fault alarms

When an error occurs, it is indicated on the display and causes the binary output for fault alarms to be activated.

An error no longer appears on the display after it has been remedied.

Error messages, their possible cause and recommended action to be taken can be found in the table below.

Note: *When an error is not described in detail in this section, we recommend to switch off the power supply and wait five seconds before switching it back on again.*

Error message	Possible cause	Recommended action
1 ERR	No access to EEPROM possible	Return the controller to SAMSON for repair.
2 ERR	EEPROM cannot be programmed	
3 ERR	Factory calibration not available	
4 ERR	Functions changed without any interaction by the user	Check the functions' settings.
5 ERR	Parameters changed without any interaction by the user	Check the parameters' settings.
6 ERR	Position of internal and external reference variable unknown	Enter internal/external reference variable.
7 ERR	Data from user calibration changed without any interaction by the user	Recalibrate the inputs and outputs.
30 ERR	Adaptation takes too long	Adaptation completed after five hours at the maximum.
31 ERR	No parameters could be determined during the start-up adaptation	Change control parameters KP, TN, TV and Y.JMP and restart start-up adaptation.
32 ERR	The signal at the X input is smaller than 0 % or greater than 100 % during the adaptation	Change Y.JMP and restart start-up adaptation.
33 ERR	Too much noise interference during the adaptation	Increase Y.JMP and restart start-up adaptation.

Error message	Possible cause	Recommended action
34 ERR	Selected PID setting does not allow an adaptation	In -CO- C.PID function, select the control algorithm P, PI or PID and restart start-up adaptation.
35 ERR	The Y signal is smaller than 0 % or greater than 100 % during the adaptation	Change Y.JMP and restart start-up adaptation.
36 ERR	Error during adaptation	Restart start-up adaptation.
255 ERR	Calibration missing	Return the controller to SAMSON for repair.
__o1	Upper limit violation of rated signal range at analog input IN1 or at analog inputs IN1 and IN2	The error message depends on how -CO- MEAS is configured (see section 6.2.3).
__u1	Lower limit violation of rated signal range at analog input IN1 or at analog inputs IN1 and IN2	
__o2	Upper limit violation of rated signal range at analog input IN2	The error message depends on how -CO- MEAS is configured (see section 6.2.3).
__u2	Lower limit violation of rated signal range at analog input IN2	

10 Infrared interface

The TROVIS 6493 Controller is fitted with an infrared interface which allows the controller to communicate with the TROVIS-VIEW interface.

Note: *The TROVIS-VIEW software is a common operator interface for various smart SAMSON devices. The software together with a device-specific module allow the configuration and parameterization of the device.*
The device-specific module for TROVIS 6493 can be downloaded free of charge from the SAMSON website (Services > Software > TROVIS-VIEW).
Additional information on TROVIS-VIEW (e.g. system requirements) can foand on the SAMSON website and in the Data Sheet T 6661 EN.

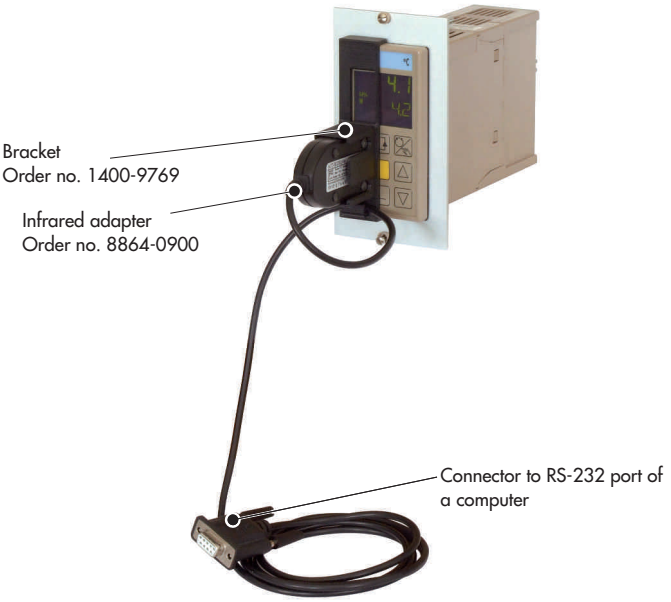


Fig. 23 · Connecting an infrared adapter

The infrared interface can be accessed from the front of the controller. It is located above the SAMSON logo (Fig. 23).

An infrared adapter (order no. 8864-0900) is required for data transmission between the serial RS-232 port of the computer and the infrared interface on the controller. A bracket (order no. 1400-9769) ensures that the adapter is properly aligned in front of the controller. The infrared adapter can be connected to the USB port of the computer using the USB to RS-232 adapter (order no. 8812-2001). For this purpose, a driver must be installed on the computer. This driver can be downloaded from the Internet at www.samson.de in Services > Software > TROVIS-VIEW > USB/RS-232 adapter (8812-2001).

Note: *To ensure data transmission functions properly, place the infrared adapter so that the distance to the infrared interface does not exceed 0.7 m and that the max. angle 25° is kept.*

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11 Appendix

11.1 Technical data

Inputs		
Analog input IN1 Analog input IN2		Two analog inputs, optionally for controlled variable X or external set point WE
		0/4 to 20 mA or 0/2 to 10 V, temperature sensor Pt 100, Pt 1000, Ni 100, Ni 1000 or potentiometer 1 kΩ
Input for current and voltage	Signal range	0/4 to 20 mA or 0/2 to 10 V
	Maximum permissible values	Current ±50 mA, voltage ±25 V
	Internal resistance	Current R_i = 50 Ω; voltage R_i = 20 kΩ
	Perm. common mode voltage	0 to 5 V
	Error	Zero < 0.2 %, span < 0.2 %, linearity < 0.2 %
	Temperature influence	< 0.1 %/10 K for zero and span*
	Resolution	< 0.0024 mA (< 0.012 % with 0 to 20 mA) (< 0.015 % with 4 to 20 mA) < 1.2 mV (< 0.012 % with 0 to 10 V)
Transmitter supply		Acc. to IEC 381 (NAMUR NE 06) 20 V DC, max. 45 mA, resistant to short circuit
Temperature sensor	For sensor	Pt 100, Pt 1000 according to DIN EN 60751 Ni 100, Ni 1000 according to DIN 43760
	Measuring range	Pt 100, Pt 1000: −100 to 500 °C Ni 100, Ni 1000: −60 to 250 °C
	Wire resistance	Three-wire $R_{L1} = R_{L2} = R_{L3}$ < 15 Ω
	Error Pt 100, Pt 1000 in the range between −40 and 150 °C	Zero < 0.2 %, span < 0.2 %, linearity < 0.2 % Zero < 0.1 %, span < 0.1 %, linearity < 0.1 %
	Temperature influence	< 0.2 %/10 K for zero and span*
	Resolution	< 0.04 °C (< 0.007 % with −100 to 500 °C)

* Based on 20 °C

Inputs		
Potentiometer	Nominal value	1 kΩ, three-wire
	Wire resistance	R_L < 15 Ω per wire
	Error	Zero < 0.2 %, span < 0.2 %
	Temperature influence	Zero < 0.1 %/10 K, span < 0.2 %/10 K*
	Resolution	< 0.07 Ω (< 0.007 %)
Binary input		Switching contact – With external supply 24 V DC (4…31 V DC) or – Powered by the controller over terminals 81, 82 (20 V DC) Signal state OFF with 0 to 2 V Signal state ON with 4 to 31 V Current consumption < 6 mA with 24 V DC < 5.5 mA with 20 V DC
Outputs		Continuous-action, on/off or three-step output
Analog output	Rated signal range	0/4 to 20 mA, load < 740 Ω 0/2 to 10 V, load > 3 kΩ
	Maximum modulation range	0 to 22 mA, 0 to 11 V
	Error	< 0.2 %
	Temperature influence	Zero < 0.1 %/10 K, span < 0.1 %/10 K
	Resolution	< 0.0015 mA (< 0.0075 % with 0 to 20 mA) (< 0.0094 % with 4 to 20 mA) < 0.75 mV (< 0.0075 % with 0 to 10 V)
Binary output BO1 Binary output BO2		Two relays with floating switching contact Max. 250 V AC, max. 250 V DC, max. 1 A AC, max. 0.1 A DC, cos θ = 1
	Spark suppression	Parallel connection C= 2.2 nF and varistor 300 V AC, in parallel to each relay contact
Binary output BO3 for fault alarms		Isolated transistor output, external supply 3 to 50 V DC, max. 30 mA
Infrared interface		
Transmission protocol		SAMSON-specific protocol (SSP)
Transmission rate		9600 bit/s
Angle of reflection		50°
Distance infrared adapter and controller		Max. 0.7 m

* Based on 20 °C

General specifications	
Display	Backlit LCD
Reading range	–999 to 9999, start value, end value and decimal separator can be selected
Configuration	Functions saved in read-only memory for fixed set point and follow-up control, one control circuit
Power supply	90 to 250 V AC; 47 to 63 Hz 24 V AC/DC (20 to 30 V AC/DC), 47 to 63 Hz
Power consumption	13 VA (90 to 250 V AC), external fuse > 630 mA (slow) 7 VA (24 V AC/DC), external fuse > 1.25 A (slow)
Temperature	Ambient: 0 to 50 °C Shipping and storage: –20 to 70 °C
Mechanical environmental testing for storage, transportation and operation	Sinusoidal vibrations acc. to IEC 60068-2-6: 2 to 9 Hz; amplitude 3.5 mm 9 to 200 Hz; acceleration 10 m/s^2 200 to 500 Hz; acceleration 15 m/s^2 Random vibrations acc. to IEC 60068-2-64: 1.0 m^2/s^3; 10 to 200 Hz 0.3 m^2/s^3; 200 to 2000 Hz Shocks acc. to IEC 60068-2-27: Acceleration 100 m/s^2; duration 11 ms
Degree of protection	IP 65 (front), IP 30 (housing), IP 00 (terminals) according to EN 60529
Device safety	Acc. to EN 61010-1: Protection class II Overvoltage category II Degree of contamination 2 Design and testing according to EN 61010
Electromagnetic compatability	Requirements according to EN 61000-6-2, EN 61000-6-3, EN 61326-1
Electrical connection	1.5 mm^2 screw terminals
Scanning time	≤ 80 ms
Weight	Approx. 0.5 kg
Compliance	CE EAC

11.1 Configuration list

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Control parameters				
PAR				
Input				
IN	**IN1**	0–20 mA	0 to 20 mA	IN1/mA
	Input signal IN1	**4–20 mA**	4 to 20 mA	IN1/mA
		0–10 V	0 to 10 V	IN1/V
		2–10 V	2 to 10 V	IN1/V
		100 PT	Pt 100 (–100 … 500 °C)	IN1/PT
		1000 PT	Pt 1000 (–100 … 500 °C)	IN1/PT
		100 NI	Ni 100 (–60 … 250 °C)	IN1/NI
		1000 NI	Ni 1000 (–60 … 250 °C)	IN1/PT
		0–1KOHM	0 to 1000 Ω	IN1/KOHM
	IN2	0–20 mA	0 to 20 mA	IN2/mA
	Input signal IN2	4–20 mA	4 to 20 mA	IN2/mA
		0–10 V	0 to 10 V	IN2/V
		2–10 V	2 to 10 V	IN2/V
		100 PT	Pt 100 (–100 … 500 °C)	IN2/PT
		1000 PT	Pt 1000 (–100 … 500 °C)	IN2/PT
		100 NI	Ni 100 (–60 … 250 °C)	IN2/NI
		1000 NI	Ni 1000 (–60 … 250 °C)	IN2/PT
		0–1KOHM	0 to 1000 Ω	IN2/KOHM
	MEAS	**oFF ME.MO**	Off	noPA MEAS/ME.MO
	Signal monitoring	IN1 ME.MO	Analog input IN1	
		IN2 ME.MO	Analog input IN2	
		ALL ME.MO	Analog input IN1 and IN2	

* The default setting is written in **bold**.

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Parameter selection	Parameter description	Value range*	Refer to section
KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]	6.1
TN	Reset time	[1 … **120** … 9999 s]	
TV	Derivative-action time	[1 … **10** … 9999 s]	
Y.PRE	Operating point	[–10.0 … **0.0** … 110.0 %]	
⊻ IN1	Lower measuring range value	[–999.0 … **0.0** … ⊼ IN1]	6.2.1
IN1	Upper measuring range value	[⊻ IN1 … **100.0** … 9999] [2]	
⊻ IN2	Lower measuring range value	[–999.0 … **0.0** … ⊼ IN2]	6.2.2
IN2	Upper measuring range value	[⊻ IN2 … **100.0** … 9999] [2]	
No parameter			6.2.3

[1] Value range is identical to that of the assigned input

[2] Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menü	Function -CO-	Setting options*	Function description	Parameter level -PA-
IN	**MAN** Switch to manual mode in case of signal failure	off FAIL F01 FAIL F02 FAIL	Off With output value Y1K1 With last manipulated variable value	MAN/FAIL
	CLAS Assignment of X to analog inputs	In2 X In1 X	X = IN2 X = IN1	noPA CLAS/X
	Assignment of WE to analog inputs	In1 WE In2 WE	WE = IN1 WE = IN2	noPA CLAS/WE
	DI.FI Filtering input variable X	**oFF X** on X	Off On	DI.FI/X
	Filtering input variable WE	**oFF WE** on WE	Off On	DI.FI/WE
	SQR Root extraction of X	**oFF X** on X	Off On	noPA SQR/X
	Root extraction of WE	**oFF WE** on WE	Off On	noPA SQR/WE
	FUNC Function generation of X	**oFF X** on X	Off On	FUNC/X
	Function generation of WE	**oFF WE** on WE	Off On	FUNC/WE

* The default setting is written in **bold**.

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Parameter selection	Parameter description	Value range*	Refer to section
Y1K1	Constant output value	[**–10.0** … 110.0 %]	6.2.4
No parameters			6.2.5
No parameters			
TS.X	Time constant of X filter	[0.1 … **1.0** … 100.0 s]	6.2.6
TS.WE	Time constant of WE filter	[0.1 … **1.0** … 100.0 s]	
No parameters			6.2.7
No parameters			
MIN	Lower range value of output signal	[–999 … **0.0** … MAX][2]	6.2.8
MAX	Upper range value of output signal	[MIN … **100.0** … 9999][2]	
K1.X	Input value 1	[⩡**IN1** … ⩠IN1], [⩡**IN2** … ⩠IN2]	
K1.Y	Output value 1	[**MIN** … MAX]	
…	…		
K7.X	Input value 7	[⩡**IN1** … ⩠IN1], [⩡**IN2** … ⩠IN2]	
K7.Y	Output value 7	[**MIN** … MAX]	
MIN	Lower range value of output signal	[–999 … **0.0** … MAX][2]	
MAX	Upper range value of output signal	[MIN … **100.0** … 9999][2]	
K1.X	Input value 1	[⩡**IN1** … ⩠IN1], [⩡**IN2** … ⩠IN2]	
K1.Y	Output value 1	[**MIN** … MAX]	
…	…		
K7.X	Input value 7	[⩡**IN1** … ⩠IN1], [⩡**IN2** … ⩠IN2]	
K7.Y	Output value 7	[**MIN** … MAX]	

1) Value range is identical to that of the assigned input

2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Set point				
SETP	**SP.VA** Internal set point W	**on W**	On	SP.VA/W
	Internal set point W2	**oFF W2**	Off	
		on W2	On	P.VA/W2
	Input variable WE	**oFF WE**	Off	noPA SP.VA/WE
		on WE	External set point WE	
		F01 WE	Input for external feedback with three-step output	
		F02 WE	Input for feedforward control	
	SP.FU Set point ramp	**oFF RAMP**	Off	
		F01 RAMP	Started with actual value by binary input BI1	SP.FU/RAMP
		F02 RAMP	Started with WIRA by binary input BI1	SP.FU/RAMP
		F03 RAMP	Without start conditions	
	Set point switchover	**oFF CH.SP**	Off	noPA SP.VA/CH.SP
		F01 CH.SP	W(W2)/WE by binary input BI1 W/W2 by binary input BI1	
		F02 CH.SP		

* The default setting is written in **bold**.

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Parameter selection	Parameter description	Value range*	Refer to section
W	Internal set point	[⊻ WRAN … **0.0** … ⊼WRAN]	6.3.1
⊻ WINT	Lower measuring range value W/W2	[–999 … **0.0** … ⊼WINT]	
⊼ WINT			
⊻ WRAN	Upper measuring range value W/W2	[⊻ WINT … **100.0** … 9999]	
⊼ WRAN			
	Lower adjustment limit W/W2	[⊻ WINT … **0.0** … ⊼WRAN]	
	Upper adjustment limit W/W2	[⊻ WRAN … **100.0** … ⊼WINT][2)]	
W2	Internal set point	[⊻ WRAN … **0.0** … ⊼WRAN][2)]	
No parameters			
TSRW	Transit time	[1 … **10** … 9999 s]	6.3.2
WIRA	Initial value	[⊻ WINT … **0.0** … ⊼ WINT][2)]	
No parameters			

1) Value range is identical to that of the assigned input

2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Controller				
CNTR	**C.PID** Control algorithm	P CP.YP **PI CP.YP** Pd CP.YP PId CP.YP PPI CP.YP	P action PI action PD action PID action P^2I action	C.PID/CP.YP C.PID/CP.YP C.PID/CP.YP C.PID/CP.YP C.PID/CP.YP
	SIGN Inversion of error XD	**dir.d XD** in.d XD	Not inverted Inverted	noPA SIGN/XD
	D.PID Assign D element to control output	**F01 DP.YP** F02 DP.YP	To error To controlled variable	noPA D.PID/DP.YP
	CH.CA Control mode selection P(D)/PI(D)	**oFF CC.P** F01 CC.P F02 CC.P	Off By error By set point	 CH.CA/CC.P CH.CA/CC.P
	M.ADJ Operating point preset by manual mode for YPID	**oFF MA.YP** on MA.YP	Off On	noPA M.ADJ/MA.YP
	DIRE Operating direction of man. variable	**dir.d DI.AC** in.d DI.AC	Direct Inverted	noPA DIRE/DI.AC
	F.FOR Feedforward control	**oFF FECO** P05 FECO nE6 FECO	Off With positive sign With negative sign	 F.FOR/FECO F.FOR/FECO
	AC.VA Increase/decrease actual value	**oFF IN.DE** bi1 IN.DE	Off By binary input BI	 AC.VA/IN.DE

* The default setting is written in **bold**.

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Parameter selection	Parameter description	Value range*	Refer to section
KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]	6.4.1
TN	Reset time	[1 … **120** … 9999 s]	
TV	Derivative-action time	[1 … **10** … 9999 s]	
TVK1	Derivative-action gain	[0.10 … **1.00** … 10.00]	
Y.PRE	Operating point	[–10.0 … **0.0** … 110.0]	
DZXD	Dead band error XD	[**0.0** … 110.0 %]	
⩡ DZXD	Minimum effective error XD	[**–110.0 %** … ⩠ DZXD]	
⩠ DZXD	Maximum effective error XD	[⩡ DZXD … **110.0 %**]	
No parameters			6.4.2
No parameters			6.4.3
CLI.P	Max. limit for PI(D) control	[–110.0 … **10.0** … 110.0 %]	6.4.4
CLI.M	Min. limit for PI(D) control	[–110.0 … **–10.0** … 110.0 %]	
No parameters			6.4.5
No parameters			6.4.6
FC.K1	Constant 1	[**0.0** … 110.0 %]	6.4.7
FC.K2	Constant 2	[0.0 … **1.0** … 100.0]	
FC.K3	Constant 3	[–110.0 … **0.00** … 110.0 %]	
AV.K1	Constant in percent (± actual value)	[–110.0 … **0.0** … 110.0 %]	6.4.8

1) Value range is identical to that of the assigned input
2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Output functions				
OUT	**SAFE**	**oFF SA.VA**	Off	
	Activate constant output value	bi1 SA.VA	By binary input BI1	SAFE/SA.VA
	MA.AU	**oFF CH.MA**	Off	noPA MA.AU/CH.MA
	Manual/automatic switchover	bi1 CH.MA	By binary input BI1	
	Y.LIM	**on LI.YP**	On	Y.LIM/LI.YP
	Control signal limitation YPID			
	RAMP	**oFF RA.YP**	Off	
	Output ramp/output rate limitation	F01 RA.YP	Output ramp, started with –10 % by binary input BI1	RAMP/RA.YP
		F02 RA.YP	Output ramp, started with Y1RA by binary input BI1	
		F03 RA.YP	Limitation when manipulated variable decreases and increases	
		F04 RA.YP	Limitation when manipulated variable increases	
		F05 RA.YP	Limitation when manipulated variable decreases	
	BLOC	**oFF BL.YP**	Off	noPA BLOC/BL.YP
	Locking manipulated variable YPID	on BL.YP	By binary input BI1	
	FUNC	**oFF FU.YP**	Off	
	Function generation of manipulated variable	on FU.YP	On	FUNC/FU.YP
	Y.VA	oFF Y	Off	no PA Y.VA/Y
	Signal range for analog output Y	0–20 mA	0 to 20 mA	no PA Y.VA/mA
		4–20 mA	4 to 20 mA	no PA Y.VA/mA
		0–10 V	0 to 10 V	no PA Y.VA/V
		2–10 V	2 to 10 V	no PA Y.VA/V

* The default setting is written in **bold**.

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Parameter selection	Parameter description	Value range*	Refer to section
Y1K1	Constant output value	[–10.0 … **0.0** … 110.0 %]	6.5.1
No parameters			6.5.2
⩡ Y	Minimum manipulated variable	[–10.0 … **0.0** … 110.0 %]	6.5.3
⩠ Y	Maximum manipulated variable	[–10.0 … **100.0** … 110.0 %]	
TSRA	Transit (running) time	[**1** … 9999 s]	6.5.4
Y1RA	Initial value	[–10.0 … **0.0** … 110.0 %]	
No parameters			6.5.5
K1.X	Input value 1	[–10.0 … **0.0** … 110.0 %]	6.5.6
K1.Y	Output value 1	[–10.0 … **0.0** … 110.0 %]	
…			
K7.X	Input value 7	[–10.0 … **0.0** … 110.0 %]	
K7.Y	Output value 7	[–10.0 … **0.0** … 110.0 %]	
No parameters			6.5.7

1) Value range is identical to that of the assigned input

2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
OUT	**Y.SRC**	**on Y.PID**	Output YPID	no PA Y.SRC/Y.PID
	Source for analog output Y	on Y.X	Input X	no PA Y.SRC/Y.X
		on Y.WE	Input WE	no PA Y.SRC/Y.WE
		on Y.XD	Error XD	no PA Y.SRC/Y.XD
	CALC	oFF CA.Y	Off (no output signal)	
	Mathematical adaptation of analog output Y	**on CA.Y**	Without condition	CALC/CA.Y
		POS CA.Y	With positive sign	CALC/CA.Y
		nE6 CA.Y	With negative sign	CALC/CA.Y
	C.OUT	**oFF 2/3.S**	Off	
	On/off or three-step output	on 2.STP	On/off output	C.OUT/2/3.S
		i.Fb 3.STP	Three-step output with internal feedback	C.OUT/2.STP
		E.Fb 3.STP	Three-step output with external feedback	C.OUT/3.STP
		PP 2.STP	On/off output with PPM	C.OUT/2.STP
		i.PP 3.STP	Three-step output with internal feedback and PPM	C.OUT/3.STP
		E.PP 3.STP	Three-step output with external feedback and PPM	C.OUT/2.STP
	B.OUT	**oFF B.BO1**	Off	noPA OUT1/B.BO1
	Binary output BO1	F01 B.BO1	Active when binary input is set	
		F02 B.BO1	Active when WE is active	
		F03 B.BO1	Active in automatic mode	
	Binary output BO2	**oFF B.BO2**	Off	noPA OUT1/B.BO2
		F01 B.BO2	Active when binary input is set	
		F02 B.BO2	Active when WE is active	
		F03 B.BO2	Active in automatic mode	

* The default setting is written in **bold**.

..... ↓ or → ..... . ↓ and , followed by ↵

Parameter selection	Parameter description	Value range*	Refer to section
No parameters			6.5.8
CA.K1	Constant 1	[**0.0** ... 100.0 %]	6.5.9
CA.K2	Constant 2	[0.0 ... **1.0** ... 10.0]	
CA.K3	Constant 3	[–10.0 ... **0.00** ... 110.0 %]	
KPL1	Gain Y+ (BO1)	[0.1 ... **1.0** ... 100.0]	6.5.10
KPL2	Gain Y– (BO2)	[0.1 ... **1.0** ... 100.0]	
TYL1	Cycle duration Y+ (BO1)	[1.0 ... **10.0** ... 9999 s]	
TYL2	Cycle duration Y– (BO2)	[1.0 ... **10.0** ... 9999 s]	
⩓ TYL1	Min. duty cycle Y+ (BO1)	[0.1 ... **1.0** s ... TYL1]	
⩓ TYL2	Min. duty cycle Y– (BO2)	[0.1 ... **1.0** s ... TYL2]	
XSDY	Hysteresis	[0.10 ... **0.50** % ... TZ]	
TZ	Dead band	[XSDY ... **2.00** ... 100.0 %]	
TY	Transit time	[1 ... **60** ... 9999 s]	
No parameters			6.5.11
No parameters			

1) Value range is identical to that of the assigned input
2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Limit relays				
ALRM	**LIM1**	**oFF L1**	Off	
	Limit relay L1	Lo L1.X	When X is not reached	LIM1/L1.X
		Hi L1.X	When X is exceeded	LIM1/L1.X
		Lo L1.WE	When WE is not reached	LIM1/L1.WE
		Hi L1.WE	When WE is exceeded	LIM1/L1.WE
		Lo L1.YP	When YPID is not reached	LIM1/L1.YP
		Hi L1.YP	When YPID is exceeded	LIM1/L1.YP
		Lo L1.XD	When XD is not reached	LIM1/L1.XD
		Hi L1.XD	When XD is exceeded	LIM1/L1.XD
		AbS L1.XD	When absolute value of XD is exceeded	LIM1/L1.XD
	LIM2	**oFF L2**	Off	
	Limit relay L2	Lo L2.X	When X is not reached	LIM2/L2.X
		Hi L2.X	When X is exceeded	LIM2/L2.X
		Lo L2.WE	When WE is not reached	LIM2/L2.WE
		Hi L2.WE	When WE is exceeded	LIM2/L2.WE
		Lo L2.YP	When YPID is not reached	LIM2/L2.YP
		Hi L2.YP	When YPIDis exceeded	LIM2/L2.YP
		Lo L2.XD	When XD is not reached	LIM2/L2.XD
		Hi L2.XD	When XD is exceeded	LIM2/L2.XD
		AbS L2.XD	When absolute value of XD is exceeded	LIM2/L2.XD

* The default setting is written in **bold**.

..... ▲ ↓ or ■ →..... .▲ ↓ and ■ , followed by ◄ ↵

Parameter selection	Parameter description	Value range*	Refer to section
LI.X	Limit for X	[⩡ IN1 … **100.0** … ⩠ IN1] [1,2) [⩡ IN2 … **100.0** … ⩠ IN2] [1,2)	6.6.1
LI.WE	Limit for WE	[⩡ IN1 … **100.0** … ⩠ IN1] [1,2) [⩡ IN2 … **100.0** … ⩠ IN2] [1,2)	
LI.YP	Limit for YPID	[⩡ Y … **100.0 %** … ⩠ Y]	
LI.XD	Limit for XD	[–110.0 … **0.0** … 110.0 %]	
LI.HYS	Hysteresis	[0.10 …**0.50** … 100.0 %]	
LI.X	Limit for X	[⩡ IN1 … **100.0** … ⩠ IN1] [1,2) [⩡ IN2 … **100.0** … ⩠ IN2] [1,2)	6.6.2
LI.WE	Limit for WE	[⩡ IN1 … **100.0** … ⩠ IN1] [1,2) [⩡ IN2 … **100.0** … ⩠ IN2] [1,2)	
LI.YP	Limit for YPID	[⩡ Y … **100.0 %** … ⩠ Y]	
LI.XD	Limit for XD	[–110.0 … **0.0** … 110.0 %]	
LI.HYS	Hysteresis	[0.10 …**0.50** … 100.0 %]	

1) Value range is identical to that of the assigned input
2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Additional functions				
AUX	**RE.CO** Restart conditions after power failure	F01 MODE **F02 MODE**	Manual, with constant output Y1K1 Auto, start with output value Y1K1	RE.CO/MODE RE.CO/MODE
	ST.IN Reset to default settings	**FrEE INIT** All INIT FUnC INIT PArA INIT AdJ INIT	Off/completed All functions, parameters and code number All functions All parameters and code number Calibration values for IN1, IN2, Y	noPA ST.IN/INIT
	KEYL Lock control keys	**oFF LOCK** bi1 LOCK on noH.W	Off Switched on/off by binary input BI1 Selector, manual/automatic and cursors keys off	noPA KEYL/LOCK
	VIEW Top/bottom viewing angle of display	01 VIEW … **06 VIEW** … 10 VIEW	Level 1 … Level 6 … Level 10	noPA
	FREQ Power line frequency	**on 50Hz** on 60Hz	50 Hz 60 Hz	noPA FREQ
	DP Decimal seperator setting	on DP0 **on DP1** on DP2	No digit One digit Two digits	noPA DP1

* The default setting is written in **bold**.

..... ↓ or → ..... . ↓ and , followed by ↵

Parameter selection	Parameter description	Value range*	Refer to section
Y1K1	Constant output value	[–10.0 … **0.0** … 110.0 %]	6.7.1
No parameters			6.7.2
No parameters			6.7.3
No parameters			6.7.4
No parameters			6.7.5
No parameters			6.7.6

1) Value range is identical to that of the assigned input
2) Decimal position depends on the DP function (AUX menu)

→ … → ..... ↓ or →..... →.....

Menu	Function -CO-	Setting options*	Function description	Parameter level -PA-
Start-up adaptation				
TUNE	**ADAP**	**oFF ADP.S**	Off	
	Start-up adaptation	run ADP.S	Start	ADAP/ADP.S
Process data				
I-O	**CIN**		Display	
	Firmware version			
	S-No		Display	
	Serial number			
	ANA	IN1	Analog input IN1	
	Display analog inputs and outputs	IN2	Analog input IN2	
		CO.VA	Controlled variable before function generation	
		WE.VA	WE before function generation	
		FE.CO	WE after function generation	
		SP.CO	Set point at comparator	
		YPID	YPID after limitation	
		YOUT	Analog output	
	BIN	BI1	Binary input BI	
	Display binary inputs and outputs	BO1	Binary output BO1	
		BO2	Binary output BO2	
	ADJ	AdJ IN1	Analog input IN1	
	Calibration	AdJ IN2	Analog input IN2	
		AdJ YOUT	Analog output	

* The default setting is written in **bold**.

..... ↓ or → ..... . ↓ and , followed by ↵

Parameter selection	Parameter description	Value range*	Refer to section
KP	Proportional-action coefficient	[0.1 … **1.0** … 100.0]	6.8
TN	Reset time	[1 … **120** … 9999 s]	
TV	Derivative-action time	[1 … **10** … 9999 s]	
Y.JMP	Step change value of manipulated variable	[–100.0 … **20.0** … 100.0 %]	
			6.9.1
			6.9.2
			6.9.3
			6.9.4
			6.9.5

1) Value range is identical to that of the assigned input
2) Decimal position depends on the DP function (AUX menu)

11.2 Configuration protocol

Menu	Function -CO-		Parameter -PA-
PAR			KP: (see also -CO- C.PID)
			TN: (see also -CO- C.PID)
			TV: (see also -CO- C.PID)
			Y.PRE: (see also -CO- C.PID)
IN	IN1:		⩡ IN1:
			⩠ IN1:
	IN2:		⩡ IN2:
			⩠ IN2:
	MEAS:		No parameters
	MAN:		Y1K1: (see also -CO- SAFE and -CO- RE.CO)
	CLAS	X:	No parameters
		WE:	No parameters
	DI.FI	X:	TS.X:
		WE:	TS.WE:
	SQR	X:	No parameters
		WE:	No parameters
	FUNC	X:	MIN:
			MAX:
			K1.X:
			K1.Y:
			K2.X:
			K2.Y:
			K3.X:
			K3.Y:
			K4.X:
			K4.Y:
			K5.X:
			K5.Y:

Menu	Function -CO-		Parameter -PA-
IN	FUNC	X (continued)	K6.X:
			K6.Y:
			K7.X:
			K7.Y:
		WE:	MIN:
			MAX:
			K1.X:
			K1.Y:
			K2.X:
			K2.Y:
			K3.X:
			K3.Y:
			K4.X:
			K4.Y:
			K5.X:
			K5.Y:
			K6.X:
			K6.Y:
			K7.X:
			K7.Y:
SETP	SP.VA	W:	W:
			⊻ WINT:
			⊼ WINT:
			⊻ WRAN:
			⊼ WRAN:
		W2:	W2:
		WE:	No parameters
	SP.FU	RAMP:	TSRA:
			WIRA:
		CH.SP:	No parameters

Menu	Function -CO-	Parameter -PA-
CNTR	C.PID:	KP: (see also **PAR**)
		TN: (see also **PAR**)
		TV: (see also **PAR**)
		TVK1:
		Y.PRE: (see also **PAR**)
		DZXD
		⩡ DZXD:
		⩠ DZXD:
	SIGN:	No parameters
	D.PID:	No parameters
	CH.CA:	CLI.P:
		CLI.M:
	M.ADJ:	No parameters
	DIRE:	No parameters
	F.FOR:	FC.K1:
		FC.K2:
		FC.K3:
	AC.VA:	AV.K1:
OUT	SAFE:	Y1K1: (see also -CO- MAN and -CO- RE.CO)
	MA.AU	No parameters
	Y.LIM	⩡ Y:
		⩠ Y:
	RAMP:	TSRA:
		Y1RA:
	BLOC:	No parameters
	FUNC:	K1.X:
		K1.Y:
		K2.X:
		K2.Y:

Menu	Function -CO-		Parameter -PA-
OUT	FUNC (continued)		K3.X:
			K3.Y:
			K4.X:
			K4.Y:
			K5.X:
			K5.Y:
			K6.X:
			K6.Y:
			K7.X:
			K7.Y:
	Y.VA:		No parameters
	Y.SRC:		No parameters
	CALC:		CA.K1:
			CA.K2:
			CA.K3:
	C.OUT:		KPL1:
			KPL2:
			TYL1:
			TYL2:
			⩒ TYL1:
			⩒ TYL2:
			XSDY:
			TZ:
			TY:
	B.OUT	B.OUT1:	No parameters
		B.OUT2:	No parameters

Menu	Function -CO-	Parameter -PA-
ALRM	LIM1:	LI.X:
		LI.WE:
		LI.YP:
		LI.XD:
		LI.HYS:
	LIM2:	LI.X:
		LI.WE:
		LI.YP:
		LI.XD:
		LI.HYS:
AUX	RE.CO:	Y1K1: (see also -CO- MAN and -CO- SAFE)
	ST.IN:	No parameters
AUX	KEYL:	No parameters
	VIEW:	No parameters
	FREQ:	No parameters
	DP:	No parameters
TUNE	TUNE:	KP:
		TN:
		TV:
		Y.JMP:

11.3 Values for resistance thermometers

Pt 100 measuring elements (values according to DIN EN 60751:2009-05)

°C	–100	–90	–80	–70	–60	–50	–40	–30	–20	–10	0
Ω	60.26	64.30	68.33	72.33	76.33	80.31	84.27	88.22	92.16	95.09	100.00

°C	10	20	30	40	50	60	70	80	90	100	110
Ω	103.90	107.79	111.67	115.54	119.40	123.24	127.08	130.90	134.71	138.51	142.29

°C	120	130	140	150	160	170	180	190	200	210	220
Ω	146.07	149.83	153.58	157.33	161.05	164.77	168.48	172.17	175.86	179.53	183.19

°C	230	240	250	260	270	280	290	300	310	320	330
Ω	156.84	190.47	194.10	197.71	201.31	204.90	208.48	212.05	215.61	219.15	222.68

°C	340	350	360	370	380	390	400	410	420	430	440
Ω	226.21	229.72	233.21	236.70	240.18	243.64	247.09	250.53	253.96	257.38	260.78

°C	450	460	470	480	490	500
Ω	264.18	267.56	270.93	274.29	277.64	280.98

Pt 1000 measuring elements

Refer to the resistance values for Pt 100 measuring elements and mulitply them by 10.

Ni 100 measuring elements (values according to DIN 43760:1987-09)

°C	–60	–50	–40	–30	–20	–10	0	10	20	30	40
Ω	69.5	74.3	79.1	84.1	89.3	94.6	100.0	105.6	111.2	117.1	123.0

°C	50	60	70	80	90	100	110	120	130	140	150
Ω	129.1	135.3	141.7	148.3	154.9	161.8	168.8	176.0	183.3	190.9	198.6

°C	160	170	180	190	200	210	220	230	240	250
Ω	206.6	214.8	223.2	231.8	240.7	249.8	259.2	268.9	278.9	289.2

Ni 1000 measuring elements

Refer to the resistance values for Ni 100 measuring elements and mulitply them by 10.

11.4 Used abbreviations

X	Controlled variable
Y	Manipulated variable
W	Internal set point (reference variable)
W2	Internal set point (reference variable)
WE	External set point (reference variable), disturbance variable, external position feedback
XD	Error
$\underline{X}$	Minimum value of a variable
$\overline{X}$	Maximum value of a variable

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